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RUSSIAN RIVER BASIN, CALIFORNIA. PRELIMINARY REPORT ON FUTURE MUNICIPAL AND INDUSTRIAL WATER USES AND FUTURE WATER QUALITY CONTROL FLOWS

Public Health Service
San Francisco, California

March 1963

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RUSSIAN RIVER BASIN

CALIFORNIA

Preliminary Report on the Future Municipal and Industrial Water Uses and Future Water Quality Control Flows

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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region IX
San Francisco, California

March 1963

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RUSSIAN RIVER BASIN

CALIFORNIA

Preliminary Report on Future Municipal and Industrial Water Uses and Future Water Quality Control Flows

Prepared at the request of

DEPARTMENT OF THE ARMY
U. S. Army Engineer District - San Francisco, California

by

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region IX
San Francisco, California

MARCH 1963

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I. INTRODUCTION

A. Purpose

The purpose of this report is to present the results of a preliminary study of future needs and uses of the water resources of the Russian River Basin. Specific objectives for the study are as follows:

1. Estimate future municipal and industrial water supply requirements in:

   a. The Russian River Basin

   b. Probable market areas outside the Russian River Basin in Marin, Sonoma, Napa and Solano Counties.

2. Estimate the need for storage for the regulation of flows for the purpose of water quality control in the Russian River.

B. Scope

The scope of this study is limited to a very preliminary assessment of the water requirements and water quality control problems as outlined in the objectives above. The study covers a time period of one hundred years (to the year 2060) in twenty year increments. Future projections of municipal and industrial water resource utilization are based on estimates of economic growth furnished by the San Francisco District Office, U.S. Army Corps of Engineers.

C. Authority and Request

The U.S. Army Corps of Engineers, San Francisco District, is preparing a comprehensive plan for the development of water resources of the Russian River Basin in California. The investigation includes consideration of approximately twenty potential multi-purpose reservoir projects throughout

the Basin. In a letter dated 4 May 1962, the U.S. Public Health Service, Region IX, San Francisco, was requested to provide information on municipal, industrial, and water quality control requirements necessary to meet the objectives outlined above.

The study has been made in accordance with:

1. Memorandum of Agreement, dated 4 November 1958 between the Department of the Army and the Department of Health, Education, and Welfare relative to Title III of P.L. 500, 85th Congress as amended by P.L. 87-88.

2. Federal Water Pollution Control Act (Public Law 84-660) as amended by Public Law 87-88.

II. SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

A. Findings

1. The Russian River drains an area of 1,485 square miles of the California Coast Range Mountains lying from 40 to 140 miles north of San Francisco. Approximately fifty four per cent of the Basin lies below 1000 feet elevation and only two per cent lies above 3000 feet. The vicinity map (Figure 1) appears at the back of this report.

2. The Basin's economy is based largely on agriculture, wood products and recreation. The total population is approximately 107,000 of which forty four per cent is located in the Santa Rosa area.

3. The Corps of Engineers has projected a total Basin population of 854,000 by the year 2060. It is expected that a major portion (per cent) of this growth will occur in the southern one-third of the Basin. The Corps of Engineers reports that in-place recreational water use such as swimming, boating and fishing is expected to increase from 280,000 visitor days in 1960 to 7,500,000 visitor days annually in 2060.

4. No water supply problems exist in the Basin at the present time. The major source of municipal water supplies is ground water. The main exception is the City of Santa Rosa which recently (1959) began to use Russian River surface water in preference to wells.

5. Major pollution problems in the Russian River do not exist at the present time. None of the known municipal or industrial wastes are discharged directly to the river during the low flow period and the effects of irrigation appear to be negligible.

3. Conclusions

1. The following table summarizes the estimated future gross annual municipal and industrial water use for Russian River Basin users and for export users:

Location	Acre Feet Per Year 1960	1980	2000	2020	2040	2060
Total In-Basin Use	15,500	39,505	65,160	106,540	137,865	158,135
Total Outside Basin Use	46,580	98,360	179,740	352,230	458,760	535,940
Total All Areas	62,080	137,865	244,900	458,770	596,625	694,075

2. The total quantity and quality of water available in the Russian River Basin appears adequate to serve future municipal and industrial in-basin uses. It appears, however, that storage of surface water will be needed to supplement supplies obtained from natural stream flow and from ground water. The timing of the future additional quantities required will be dependent upon the additional development of available ground water supplies and the allocation between in-basin and export users of available surface storage in Lake Mendocino and in the authorized storage project on Dry Creek.

3. It has been determined that additional municipal and industrial water supplies will be needed by 1980 in the out-basin areas of Sonoma Creek Basin and Marin County and, by the year 2000, in the Napa Valley (including Vallejo).

4. The maintainance of high water quality (as expressed by dissolved oxygen levels greater than 5 ppm) in the Russian River is necessary to preserve the recreational and fishery uses of the river. Maintainance of this standard should also provide adequate quality for withdrawal uses (municipal, industrial and irrigation).

5. Based on the existing hydrology and waste discharge practices, there is no need for storage for water quality regulation flows in the Russian River at present.

6. There is a distinct possibility that about 75% of the total treated waste generated in the Russian River Basin in the future will be applied to land or be collected in a master drain and discharged (after treatment) to the Pacific Ocean. If this occurs, the total residual waste (after treatment) that could be discharged to the Russian River would not require supplemental flows from storage because projected future minimum flows (125 cfs or greater) would be adequate.

7. Information on yields and unit costs of potential alternative single purpose storage reservoirs indicates that costs may range from $5.00 to above $14.00 per acre foot of water yield. For preliminary planning purposes a basin wide average benefit of $12.00 per acre foot for future additional municipal and industrial water supplies within the basin appears to be reasonable.

8. Based upon the costs for raw water from the most likely alternative source (the North Bay Aqueduct), the benefit per acre foot of future additional municipal and industrial water supplies in the export areas is estimated to be $19.00 per acre foot delivered to Napa Valley, $27.00 per acre-foot to Sonoma County, and $29.00 per acre-foot delivered to Marin County.

C. Recommendations

This report has been prepared on the basis of existing available data which are limited. While the material contained in this report is considered suitable for preliminary planning purposes, it should be augmented

with additional investigations and data if it is to be used in the preparation of a comprehensive water resources development plan for the Russian River Basin. It is recommended that the following additional items be considered:

1. A detailed hydrologic field investigation should be made of the ground water interrelationships to allow more accurate determination of total available water resources within the Basin.

2. Field investigations should be conducted to:

(a) refine the assumptions used in this report regarding the organic waste assimilative capacity of the river;

(b) determine the present and potential effects of uncontrolled urban and rural runoff on water quality;

(c) evaluate other water quality parameters and their relationship to water use. For example, a determination should be made of what levels of nitrogen and phosphorous can be tolerated in the Russian River.

3. Investigation should be made regarding the effects of reservoir operation on water quality, e.g. turbidity and temperature.

4. A more extensive study should be made of the relative merits of different waste disposal schemes with an expanded consideration of the benefits created by each scheme and the comparative costs.

III. DESCRIPTION OF STUDY AREA

A. The Russian River Basin

The southern boundary of the Russian River Basin lies about 40 miles north of San Francisco. The Basin extends for another 100 miles in a northerly direction, paralleling the California shoreline, but lying inland from the coast, as shown in Figure 1. The Basin lies in two counties: Sonoma County accounts for the southern two-thirds of the area, with the remainder of the area in Mendocino County, a total two county area of 950,000 acres.

1. Physical Description

"The Russian River drains an area of 1,485 square miles of the Coast Range Mountains of Central California. The river has its source about 16 miles north of Ukiah and flows southerly through the Redwood, Ukiah, Hopland and Alexander Valleys and intervening canyon reaches. The river turns west below Healdsburg, crosses the northern portion of the Santa Rosa plains to Mirabel Park, and then flows through a mountainous canyon to the Pacific Ocean at Jenner. The total length of the river is about 100 miles. Basin width varies from 12 to 32 miles. The Basin lies between two adjacent Ranges of the Coast Range Mountains... Approximately 54 percent of the area lies at elevations less than 1,000 feet and only 2 percent of the area is above 3,000 feet." [1]

2. Meteorology - Climate

a. "The climate of the Russian River Basin is typical of Central California coastal areas. Winters are wet and cool and summers warm and dry, except along the immediate coast where offshore winds

and diurnal advective fogs lower the summer maximum temperatures... Ninety-three percent of the rainfall occurs during the rainy season (Oct.-May) with 82 percent falling within the five-month period November through March."[2]

b. "The normal annual precipitation for the entire 1,485 square mile Russian River area is 41 inches. The normal precipitation is variable over the Basin, ranging from 22 inches over the southern portion of the Santa Rosa Plain to over 80 inches on the highest areas of the surrounding mountains."[3]

B. Economic and Social Factors

The Russian River study basin supported a population of about 107,000 people in 1960, divided between two counties: 18,600 people in Mendocino County and 88,400 people in Sonoma County. The "base" industries for the Basin are agriculture, wood products and recreation. Approximately 12 percent of the total basin employment is in agriculture, with another 5 percent in food processing. Logging accounts for less than 1 percent of employment, but wood processing causes about 10 percent of the employment. The 1960 and 2060 Population Projections are shown in Table 1. A detailed breakdown of population and employment projections will be found in Appendix A.

The Corps of Engineers adds the following comments to these projections: "Portions of the Basin may be expected to undergo marked economic change, most of which will probably occur in and about presently developed areas. As a result, it may be anticipated that during the next hundred years, the very large amount of unused and undeveloped land within the Basin (more than one-third of the total land area) will remain virtually unchanged.

TABLE 1

POPULATION PROJECTIONS, 1960 - 2020 - RUSSIAN RIVER BASIN

(Shown by Census Divisions)

County and Census Division a/	1960 b/	2060
Mendocino County:		
Redwood - Potter Valley	4,400	23,000
Ukiah & Ukiah Rural - Talmage	12,600	59,000
Hopland	1,600	13,000
Sonoma County:		
Cloverdale - Geyserville	7,900	50,000
Healdsburg	11,500	63,000
Santa Rosa Complex c/	46,900	442,000
Petaluma Rural d/	2,600	45,000
Sebastopol	11,800	113,000
Russian River	7,700	46,000
Basin Total	107,000	854,000

a/ U.S. Census Bureau "Census Divisions" as shown in 1960 Census of Population. The following census divisions are bisected by the basin boundaries: Redwood-Potter Valley, Hopland, Russian River Coastal, Petaluma Rural and Sebastopol.

b/ Estimate Based on 1960 Census of Population.

c/ Combining census divisions of Santa Rosa, Santa Rosa North and South Park.

d/ Does not include the City of Petaluma.

Two main forces are expected to be the dominant factors in shaping future land use patterns within the Basin: the first and more important is the anticipated growth of the San Francisco Bay area to which the Basin is economically and culturally tributary; the second is the anticipated development of recreational facilities within the Basin. The economic and cultural developments anticipated within the Basin should result in the following basic changes in land use:

1. A degree of urban development which will make comparatively small incursions on lands presently in agricultural use. However, most of the projected displacement of agriculture will probably occur in the low-lying crop lands, leaving the extensive acreage of grazing land almost unchanged.

2. Increasingly intensified use of crop land remaining in agricultural production.

3. The successive utilization for agricultural production of all presently unoccupied or unused lands suitable for that purpose.

It is believed that the ultimate economically and physically supportable development of the San Francisco Bay Area will be approached during the next hundred years. Since it is improbable that the economy of the Russian River Basin will develop independently of that of the San Francisco Bay Area, the ultimate economically supportable development of the Basin will also be approached during the next hundred years."[4]

IV. HYDROLOGY AND WATER QUALITY — DETERMINANTS OF WATER AVAILABILITY

This section will be oriented toward a discussion of hydrology, both surface flows and ground water, under present conditions. The impact of future developments will be appraised in later sections.

A. Hydrology of Surface Waters

The runoff in the Russian River Basin corresponds closely to the rainfall pattern, as there is negligible snow melt. The seasonal pattern for 1961 at several gaging stations is presented in Table 2. Table 2 also shows average yearly runoff at these stations for the period of record.

The summer flow in the Russian River is augmented by a diversion from the Van Arsdale Reservoir on the Eel River through the Potter Valley Power House into the East Fork of the Russian River. No stream flow records exist for the period before this diversion began. The operation of Lake Mendocino-Coyote Dam Reservoir on the East Fork began in 1958, and the releases from this reservoir have served to "re-regulate" the diversion from the Eel River.

The operation schedule of Lake Mendocino-Coyote Dam Reservoir calls for the release of sufficient water from the reservoir to maintain flows of 125 cfs at Guerneville, (for recreational enhancement) about 82 miles downstream from the dam and 14 miles from the Pacific Ocean. Additional releases will be made to permit diversions for domestic, municipal, irrigation and industrial use.

TABLE 2

RUNOFF PATTERNS IN THE RUSSIAN RIVER BASIN[a/]

Water Year - 1961

Station	Drainage Area (Sq. Mi.)	1961 Flow in 1,000 Acre-Feet (by month) Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Avg. Yearly Flow 1000AcFt/Yr
Russian River near Ukiah	99.6	-	3	26	8	36	32	7	4	1	-	-	-	128
East Fork Russian River near Ukiah	105	15	17	4	22	41	40	21	16	15	21	24	22	240
Russian River near Hopland	326	16	26	58	36	108	109	41	24	17	20	23	23	510
Russian River near Cloverdale	502	14	23	86	52	142	132	41	25	17	19	22	23	729
Russian River near Healdsburg	791	15	30	140	82	212	176	60	35	19	18	19	21	1,018
Russian River near Guerneville	1,342	14	28	214	130	390	269	71	37	19	17	19	21	1,605
Monthly Runoff as Percent of Yearly Runoff at Guerneville		1.2	2.3	17.4	10.6	31.7	21.9	5.7	3.0	1.5	1.5	1.5	1.7	-

a/ Source: U.S. Geological Survey, "Surface Water Records of California," Vol. 1, 1961.

Because the Eel River diversion has averaged around 10,000 acre feet per month during the summer months, the Coyote Dam Reservoir has a higher seasonal yield than the watershed would normally allow. The July-September 1961 releases exceed 20,000 acre-feet per month. The effect of this project and the Eel River diversion has been to alter enormously the low flow characteristics of the Russian River. The streamflow in the Russian River shows rapid recession in the summer as Table 2 shows for the station "Russian River near Ukiah," a relatively undisturbed watershed above the East Fork, where a September flow of 11 acre-feet per month was recorded for a drainage area of 99.6 square miles.

There are several more large projects proposed for the Russian River Basin, including a second stage for the Coyote Dam Reservoir which could provide approximately 75,000 acre-feet/year of water conservation yield. In addition, an authorized project on Dry Creek will provide 90,000 acre-feet/year of water conservation yield. These projects are schematically shown in Figure 2, which also gives some data on each.

The consequence of the combination of several projects with the possible water use schedules will probably be a well regulated stream system, with minimum flows far exceeding natural summer flows. The minimum regulated flow of 125 cfs is likely to occur at Guerneville which is located below most diversions. This situation exists at present, as shown in Table 2, for the months of June-September. The difference between the stream flow at Ukiah and that at Guerneville will probably be greater, in the future, as a consequence of several possible diversions out of the Basin and future uses within the Basin, occurring between Ukiah and Guerneville.

B. Quality of Surface Waters

Data on the quality of the Russian River have been collected since 1951 by the California State Department of Water Resources through their monthly water quality monitoring program. Samples have been collected at four or more

stations on the Russian River system. The ranges of some of the more important water quality parameters are shown in Table 3. An analysis of the seasonal pattern of total dissolved solids concentrations at two sampling stations on the Russian River is illustrated in Figure 3. This analysis covers the ten year period 1951 to 1961 for an upstream (river mile 111) and a downstream (river mile 19) location. This analysis indicates a small variation in TDS at each station and a relatively small difference between stations (50 - 80%).

Based on available information, it can be concluded that quality of the Russian River water is generally excellent, with two exceptions. Median coliform concentrations reaching 20,000 - 60,000 MPN have occurred in winter months. These can be partially attributed to direct discharges of treated wastes to the stream in winter months. There is a recurring high turbidity problem in the stream which is presently being studied by the Corps of Engineers to determine its cause and prevention.

C. Ground Water Occurrence

Ground water occurs principally in the valleys and river channels of the Russian River Basin. Three distinct ground water areas comprise the Russian River Basin. These are the Lower Russian River Valley below Cloverdale; the Upper Russian River Valley, above Cloverdale; and the Santa Rosa Plain. These areas are represented on Figure 4 and a brief description of each is shown on this figure.

Although storage capacities for each area have been estimated, no ground water yield estimates have been made. The yield of the major ground water basins is related to surface flows and permeability. The ground water occurrence along the Russian River is hydraulically connected with the surface flows, meaning that ground water recharge from surface flow in the river channel

TABLE 3

RANGE OF SURFACE WATER QUALITY
RUSSIAN RIVER BASIN a/

Station b/	ppm Chlorides Max.	ppm Chlorides Min.	ppm Hardness as $CaCO_3$ Max.	ppm Hardness as $CaCO_3$ Min.	TDS ppm Max.	TDS ppm Min.	ppm Dissolved Oxygen & % Sat. Max.		ppm Dissolved Oxygen & % Sat. Min.		Temperature °F Max.	Temperature °F Min.	pH Max.	pH Min.
					1957									
10a	5.8	1.1	102	56	142	81	13.8	111	8.2	93	72	42	8.5	7.1
8a	8.0	2.7	110	66	150	98	14.0	117	8.4	81	74	46	8.1	6.9
9	7.3	3.7	137	72	195	108	13.2	114	7.4	84	74	48	8.4	7.1
10	11.0	4.5	142	93	206	140	11.4	98	1.4	14	76	48	8.0	7.1
					1958									
10a	5.5	1.5	96	46	133	67	12.4	106	8.4	84	70	45	8.6	7.4
8a	6.5	2.4	102	52	113	82	11.4	100	8.0	93	75	46	8.4	7.3
9	9.5	1.5	136	59	182	85	12.0	106	7.0	82	75	45	8.5	7.2
10	12.0	3.5	140	56	187	84	11.6	102	8.0	97	78	50	8.5	7.2
					1959									
10a	5.2	2.8	94	54	99	73	11.3	89	8.0	89	70	42	7.7	7.3
8a	9.0	3.2	88	70	126	107	11.0	113	7.6	79	71	48	7.9	7.1
9	14.0	4.2	142	78	220	122	10.6	98	8.0	83	77	50	7.9	7.3
10	10.0	5.1	133	95	193	137	11.3	102	6.8	80	78	48	7.7	7.1
					1960									
10a	9.0	3.0	97	44	149	65	12.2	94	8.1	88	68	38	7.5	7.2
8a	10.0	3.5	97	60	143	93	10.6	86	8.0	81	70	42	7.7	7.2
9	10.0	4.0	122	80	165	115	11.2	95	7.5	83	76	47	7.9	7.0
10	13.0	5.0	122	40	170	89	10.1	86	7.6	85	72	47	7.9	7.1
					1961									
10a	5.2	0.7	80	47	113	69	11.5	90	8.2	86	68	41	7.9	7.2
8a	5.5	1.5	93	69	128	100	11.5	99	7.8	69	72	48	7.7	7.3
9	6.8	2.2	132	88	177	123	11.9	101	7.7	88	75	47	8.1	7.4
10	6.5	2.5	127	81	180	123	11.2	94	8.2	88	76	46	8.1	7.3

a/ Data obtained from California State Department of Water Resources.

b/ Station 10a is on East Fork at Potter Valley Power House; Station 8a is near Hopland; Station 9 is near Healdsburg; Station 10 is near Guerneville

is feasible. This procedure of utilizing surface water flows in the summer to supply the ground water basins is used for the Wohlert Bridge Pumping Plant, below Healdsburg, which has a pumping capacity of 3,600 acre-feet/month. The dry weather flow in the Russian River decreases about 4,000 - 5,000 acre-feet per month in passing from Ukiah to Guerneville, as seen for the months of July and August 1961. Part of this loss is due to direct diversion from the river, and part may be attributable to percolation into the streambed for recharge of the ground water basin. Evaporation is considered negligible.

D. Quality of Ground Water

In general, the chemical quality of the ground water in the lower Russian River Valley is good except for the tidal reach which is affected by salt water intrusion. The ground water is of the magnesium-calcium bicarbonate type, with a hardness of about 150 ppm and a relatively low concentration of dissolved solids. There is considerable local variation in quality range with some wells having extremely hard water with high iron concentrations.

In the upper reaches of the Russian River Basin the alluvial ground water is good quality except in several local areas where it is mixed with water of high boron content that probably migrates upward from underlying bedrock. The water is a moderately hard to hard bicarbonate type. Water from the deeper wells is somewhat poorer in quality with higher concentrations of dissolved solids.

Chemical analyses of water collected from wells in the Santa Rosa Valley area indicate that the quality of ground water is generally satisfactory

for most uses. The waters are of a calcium-magnesium-sodium bicarbonate type with a dissolved solids range between 250 and 350 ppm.

Table 4 lists some data on the ground water quality in the Russian River Basin.

TABLE 4
SUMMARY OF GROUND WATER QUALITY IN THE RUSSIAN RIVER VALLEY

Area	Total Dissolved Solids (ppm)	Hardness as $CaCO_3$ (ppm)	Chlorides (ppm)	Sodium (%)	Boron (ppm)	Iron and Manganese (ppm)	pH	T °F
Russian River Valley [a]								
Lower Russian River Valley	120-210	80-220	Low except in tidal areas	Low except in tidal areas	<0.5 [c]	<0.1 [c]	Generally Alkaline	60
Healdsburg Area	90-500	40-345	Low	50	<0.5 [c]	<0.1 [c]	Generally Alkaline	56-65
Alexander Valley	140-500	75-300	<25	<50	0.5 [c]	Low	7-8.7	60-66
Cloverdale Valley	150-600	14-230	3-110	8-90	0.3-2.9	Low	6.8-8.2	56-66
Sanel Valley	143-327	96-230	4.8-16	5-38	0.02-3.4	0.1-9.5	6.7-7.9	-
Ukiah Valley	100-1,030	78-272	4.8-466	0-88	0.1-73	0.-73	6.5-8.0	56-60
Potter Valley	140-395	105-345	Low	<20	0.61-1.0	High in some wells	6.6-7.9	64
Santa Rosa Area [b]								
Glen Ellen Formation	106-427	15-3.90	7-69	40-70	2.5-22	0.3 [c]	7.5	-
Merced Formation	205-350	35-220	9-85	<50	<0.54	0.2 [c]	7.1-9.1	-
Sonoma Volcanics	93-404	100-145	~ 30	40-45	<0.64	0.2 [c]	7.-8.5	-

a/ Data obtained from U.S. Geological Survey open file report "Geology and Ground Water in Russian River Valley Areas and in Round, Laytonville and Little Lake Valleys, Sonoma and Mendocino Counties, California," 1961.

b/ Data from Geological Survey Water Supply Paper 1427 "Geology and Ground Water in the Santa Rosa & Petaluma Valley Areas, Sonoma County, California," 1958.

c/ Local exceptions.

V. WATER USE - A FUNCTION OF WATER AVAILABILITY

This section of the report presents existing data and projections of future water use. The withdrawal water uses are not separated into consumptive and non-consumptive categories; rather, the numbers represent a gross water use.

A. Present Municipal Water Users

Present municipal water supplies are described in Table 5. Reliance on wells is evident from examining this table. The large exception is Santa Rosa, which began to use Russian River water in 1959. Before this time, Santa Rosa relied on 18 wells, a creek and a spring. Chlorination is the only treatment for the water systems listed.

B. "In-Place" Water Use

The appeal of a clean stream located in pleasant surroundings has attracted extensive recreational use (swimming, boating) to the Russian River, particularly the lower reaches below Santa Rosa. The number of water-oriented users may reach several hundred thousand yearly and there are many permanent and seasonal homes located along the river.

The Russian River also supports a fishery, both anadromous and fresh water species. Present fishing use is around 50,000 fisherman days per year.

C. Future Water Use, Municipal, Industrial and "In-Place" Users

Future gross withdrawal estimates can be divided into two categories: in-basin users and export users. The estimated in-basin use for municipal

TABLE 5

PRESENT MUNICIPAL WATER FACILITIES - RUSSIAN RIVER BASIN

Community	Est. Pop. Served	Water Use MGD	Source	Treatment	Source
Calpella					
Calpella Co. W.D.	250	x	Well	Chlorination	PHS 775
Ukiah	10,500	x	Wells	Chlorination	PHS 775
		0.8-2.0			DPH Report
Ukiah					
Millview Co. W.D.	435	x	Wells	Chlorination	PHS 775
Ukiah	2,250	0.213	Wells	None	PHS 775
Willow Co. W.D.		0.04-0.2	Wells (1953)	Chlorination	DPH Report
Hopland	x	x	x	x	
Cloverdale	2,833	0.500	Wells	None	PHS 775
		0.3-0.75	Wells (1950)	x	DPH Report
Geyserville	x	x	x	x	
Healdsburg	3,987	0.360	Wells	None	PHS 775
	4,000	0.35-1.5	Wells (1952)	Chlorination	DPH Report
Healdsburg	1,000	0.30	Wells	Hypochlorite plus Fluoride	PHS 775
Sciarra W.C.		0.03-0.05			DPH Report
Santa Rosa	37,200	5.43	Russian River	Chlorination	PHS 661-62
Sebastopol	3,000	0.5	Wells	None	PHS 775
		0.2-0.6	Wells		
Sebastopol	600-1,400	0.02	Wells, Creek Spring	x	
Russian River Terrace W.C.					
Cotati P.U.D.	800	x	Well	Hypochlorite	PHS 775
Monte Rio-Guerneville	5,000	x	Creek, Springs Wells	Hypochlorite	PHS 775
Citizens Utility Corp. of Calif.		0.08-0.41			PHS Report

x - Data not Available

a/ Sources: PHS 661-62: Unpublished Public Health Service Data
PHS 775: U. S. Public Health Service, "Municipal Water Facilities - Inventory as of Jan. 1, 1958," Public Health Service Pub. No. 775, Vol. 9, 1960
DPH Report: State of Calif., Dept. of Public Health, "California Domestic Water Supply Statistics," 1958.

and industrial water supply is shown in Table 6 for the period 1960-2060. The forecasting method and data used are shown in Appendix A.

Out-of-the-basin or export withdrawal users are located in three areas: Petaluma and Sonoma Creek, Napa Valley Area and North Marin County, as shown in Figure 5. The Petaluma and Sonoma Creek and North Marin County areas receive Russian River water at present. The future water uses for the areas were estimated with less precision than the in-basin future water uses, as explained in Appendix A. The out-of-basin estimates for the period 1960-2060 are also shown in Table 6.

In-place water use is expected to increase 27-fold in the next 100 years. Swimming, fishing and boating are expected to increase from an estimated 280,000 visitor days annually in 1960 to 7,500,000 visitor days annually in 2060. (Appendix A, Table A-4 and A-5 show detailed forecasts).

TABLE 6

FUTURE MUNICIPAL & INDUSTRIAL WATER USE - RUSSIAN RIVER BASIN & EXPORT AREAS

Acre-Feet Per Year

Area	1960	1980	2000	2020	2040	2060
WITHIN THE RUSSIAN RIVER BASIN						
Cloverdale-Geyserville	1,460	3,400	4,920	7,400	9,710	10,940
Healdsburg	1,490	2,900	4,650	7,935	9,930	11,100
Santa Rosa	5,550	17,750	32,740	55,290	70,240	80,040
Petaluma Rural	290	770	1,530	4,120	6,640	8,565
Sebastopol	2,140	5,670	8,870	13,060	17,490	20,485
Russian River, Coastal	880	1,510	2,740	5,030	6,400	7,960
Redwood-Potter Valley	600	1,150	1,835	2,745	3,635	4,205
Ukiah	2,830	5,700	6,730	9,320	11,810	12,730
Hopland	260	655	1,145	1,640	2,010	2,380
Basin Total	15,500	39,505	65,160	106,540	137,865	158,405
OUTSIDE RUSSIAN RIVER BASIN						
SONOMA CREEK BASIN						
Petaluma C.D. a/	3,020	6,850	22,400	52,300	75,000	85,600
Sonoma a/	2,630	9,130	16,600	24,000	28,800	30,800
Santa Rosa N. a/	150	1,140	3,450	5,100	6,480	7,050
Total	5,790	17,120	42,450	81,400	110,280	123,450
MARIN COUNTY						
Novato	3,400	8,940	17,000	52,000	60,700	71,400
North Coastal	170	260	360	1,160	1,880	2,690
San Rafael Et Al	13,900	19,400	29,600	65,600	81,700	92,500
Mill Valley Et Al	5,670	12,900	23,400	31,200	37,200	43,000
San Geronimo Valley	330	1,040	1,830	4,570	7,200	8,900
Total	23,470	42,540	72,190	154,530	188,680	218,490
NAPA VALLEY & VALLEJO COMPLEX						
Napa River Valley						
Reach 1A, I, II, III, IV	9,000	18,500	31,400	56,200	73,200	86,000
Reach V (Vallejo Complex)	8,320	20,200	33,700	60,100	86,600	108,000
Total Outside	46,580	98,360	179,740	352,230	458,760	535,940

a/ Areas receiving Russian River water at present.

VI. WATER QUALITY CONTROL FLOWS – A FUNCTION OF WATER USE

A. Water Quality Criterion

The water quality parameter chosen to determine water quality control flows is the dissolved oxygen (D.O.) content of the water. A paramont consideration in the Russian River is to provide a water quality satisfactory for the anadromous and fresh water fishery. The usual minimum stream standard for anadromous fish is at least 5 ppm D.O. and preferably 7 ppm in spawning areas. Maintaining these D.O. levels will also help to provide an aesthetically pleasing river for swimming and boating, as D.O. levels are a rough measure of the biological health of a stream. Dissolved oxygen is not an important quality parameter to most withdrawal users per se. However, by maintaining a high level of D.O., withdrawal users can generally be assured of adequate water quality as measured by other parameters.

Other water quality parameters, such as nutrients, pesticides and chlorides could be more important in the future. The present interest of the North Coastal Regional Water Pollution Control Board has been to set D.O. and bacteria controls and standards. The agricultural activities in the basin have not caused any detectable problems and no significant increase in agricultural activity is expected in the future. Chlorides and total dissolved solids are very low and of no forseeable importance. Pesticides are best controlled at the source. Nutrients do not appear to be a problem at present or in the near future. Improving treatment technology may control nutrients before they can become a problem in the Russian River Basin.

Because the dissolved oxygen content seems to be the dominant quality consideration for Russian River water at present and in the future, a minimum D.O. level of 5 ppm for the May-November season was chosen to protect

recreation and fishery in the river. A higher D.O. level, 7 ppm was chosen for the December-April season to provide the higher quality water necessary for the successful spawning of anadromous fishes. These two seasonal D.O. levels form the basis of water quality calculations in this report.

B. Present Sources of Waste Water

The present sources of municipal wastes are listed in Table 7. None of these municipal wastes are discharged directly to the river during the low flow summer months. Known industrial wastes are listed in Table 8. None of the known industrial wastes are discharged to the river in the summer.

The present quality of the Russian River water appears to show no measurable effect from municipal, industrial or agricultural wastes. Secondary treatment of domestic sewage is provided for most sources, as shown in Table 7.

C. Future Sources of Waste Water

The expected population growth in the Russian River basin will develop from 3 bases: manufacturing and processing of "raw materials" - food and timber, recreational attraction, and an "overflow" of population from the Bay Area. No unusual industrial growth is expected, and industrial wastes are not expected to be a serious problem in the future.

The calculations of future waste loads are shown in Appendix B. An explanation of their derivation accompanies the results of the calculations. Table 9 summarizes the waste loads.

D. Location of Future Waste Discharges and Required Water Quality Regulation Flows

The treated sewage - return flow from municipal and industrial users

TABLE 7

PRESENT MUNICIPAL WASTE WATER SOURCES

RUSSIAN RIVER BASIN[a/]

Community	Estimated Population Served	Avg. Daily Flow (MGD)	Design - MGD	Flow P.E. 1000's	Treatment	Discharge To	Source
Calpella	(500) - 365	x 0.01 x	x		Imhoff Tank to Lagoon	Percolation Bed	PHS 1749 BSE Report NCRWPCB Files
Ukiah	(9,900) 13,000 9,820	1.2 1.25 Dry Weather	2.5	27.0	Settling Tanks & Standard Filter Chlorination Oxidation Lagoon	Russian River	PHS 1749-1 BSE Report NCRWPCB Files
Hopland		x	x		No System	x	PHS 622
Cloverdale	3,200 5,000 3,500	.280 .300 0.5	2.016	7.0	Settling Tanks & High Cap. Filter Chlorination & Ponding	Russian River in Winter	PHS 1749-1 BSE Report NCRWPCB Files
Geyserville	-	-	-	-	-	-	No Data
Healdsburg	4,900 4,000 5,000	0.360 - 0.5	0.50	7.0	Settling Tanks High Capacity Filter Chlorination	Land-Summer Dry Creek	PHS 1749-1 BSE Report NCRWPCB Files
Santa Rosa	(31,027) 38,000 x	x 4.5 4.9	5.0	54.5	Settling Tanks High Capacity Filter Chlorination	Land-Summer Santa Rosa Creek Winter	PHS 1749-1 BSE Report NCRWPCB Files

(continued)

TABLE 7 (CON'T)

Community	Estimated Population Served	Avg. Daily Flow (MGD)	Design - MGD	Flow P.E. 1000's	Treatment	Discharge To	Source
Santa Rosa Piner-Oliver School District	225	0.002	.004	.450	Septic Tank	Land	PHS 1749-1
Santa Rosa	1,280	0.147	.360	6.00	Settling Tank	Laguna de	PHS 1749-1
Rohnert Park CSD	1,200-1,500	0.15			Oxidation Lagoon	Santa Rosa	BSE Report
Sebastopol	(2,694)	x	x	x	Settling Tanks	Laguna de	PHS 1749-1
	2,800	0.3			High Capacity Filter	Santa Rosa	BSE Report
	2,500	x					NCRWPCB Files
Graton	(1,055)	x	x	x	Oxidation Lagoon	Land	PHS 1749-1
Cotati	800	0.060	.10	1.00	Settling Tanks	Laguna de	PHS 1749-1
	800	0.08			Oxidation Lagoon	Santa Rosa	BSE Report
Forestville CSD	500	x	x	x	Imhoff Tank	Green Valley	PHS 1749-1
	525	0.05			Oxidation Lagoon	Creek	BSE Report
Monte Rio	(200)				No System		PHS 622
Windsor	(1,047)				No System		PHS 622
Ukiah	3,100	.64	x	x	Settling Tanks	x	BSE Report
Mendocino State Hospital					Two Stage Filter		

a/ Source: 1) PHS 1749-1 Unpublished U.S. Public Health Service Data
2) BSE Report Data from the California State Department of Public Health - Bureau of Sanitary Engineering
3) NCRWPCB Files Data from the North Coastal Regional Water Pollution Control Board, State of California - Santa Rosa, California

TABLE 8 [a/]

PRESENT KNOWN INDUSTRIAL WASTE WATER SOURCES

RUSSIAN RIVER BASIN

Community	Industry	Treatment	Discharge To	Remarks
Calpella	Durable Plywood Co.	Mill Pond	Russian River	
	Thrasher Lumber Co.	x	Russian River	
Cloverdale	Green Valley Lumber Co.	Mill Pond	Russian River	
	Mollala Forest Products	Mill Pond	Land	Saw Mill
Graton	Halberg Apple Pack. Co.	Septic Tank	Land	
	Manzone Prods. Co., Inc.	x	x	
	Hunt Foods, Inc.	x	Land	
Guerneville	Sonoma Quick Silver Mining Co.	Septic Tank	x	
Healdsburg	Evart Meat Co.	Septic Tank	Land	
	Larson Lumber Co.	Mill Pond	Russian River	
	Miller Fruit Co.	x	Land	
	Sonoma Dist. Coop. Dryer	Septic Tank	Land	
	Standard Structures, Inc.	Mill Pond	Land	
Santa Rosa	Calif. Wood Prods., Inc.	x	x	
	Mollala Forest Prods., Co.	Mill Pond	x	
Sebastopol	Molina Coop.	x	Land	
	Sebastopol Apple Growers Union	Screen, Lagoons	Creek	
	Dicks Smoked Meat Prods.	x	Land	Brine hauled away in Barrels
	Vacu-Dry Co.	x	Land	
Ukiah	Garret & Co.	Lagoon	Russian River	
	Masonite Corp.	Evap., Chlor. or Neutralization	[b/]	Approx. 1,000 gph Evap. Condensate
	Arthur B. Siri	Mill Pond	Land	
	Ford Gravel Co., Inc.	Settling Pond	Land	
	Ukiah Gravel Cement Co.	x	Russian River	

[a/] Source: USPHS, Public No. 622 Vol. 9, "1957 Inventory-Municipal and Industrial Waste Facilities and Calif. Dept. of Public Health Data.
x - Data not available.

[b/] Discharge To - Land and Russian River

TABLE 9

POLLUTION LOADS REMAINING AFTER TREATMENT-RUSSIAN RIVER BASIN[a/]

#BOD per day

Contributing Area	1960	2010	2060
Redwood-Potter Valley	160	560	1,020
Ukiah	710	2,170	3,420
Hopland	70	340	580
Cloverdale-Geyserville	440	1,710	2,980
Healdsburg	450	1,520	2,620
Santa Rosa	1,750	10,900	19,350
Petaluma	100	700	2,120
Sebastopol	510	2,800	5,000
Lower Russian River	220	880	1,770

a/ Computations based on:

1960:lbs. Ultimate BOD/P.E. = 0.24

2010:lbs. Ultimate BOD/P.E. = 0.30

2060:lbs. Ultimate BOD/P.E. = 0.30

Pollution Load = P.E. X lbs. BOD/P.E. X 0.10 (% BOD remaining after treatment).

may be handled several ways:

1. Direct discharge to the Russian River

   a. after normal secondary treatment (80-90% removal of 5-Day BOD)

   b. after a high degree of secondary (90-95% removal of 5-Day BOD)

2. Disposal to land

   a. sewage farms

   b. use for irrigation during the growing season, discharge to the river otherwise.

3. Transport to the ocean and dispose offshore.

Alternative 1 Direct discharge to the Russian River during all seasons may become necessary when return flows increase in the future.

There are two variants on the return flow to the stream, the choice depending on both economics and public policy.

Choice a Discharging all wastes to the Russian River after normal secondary treatment, at an assumed treatment efficiency of 90 percent, requires the total stream flows shown in Table 10, Case I for adequate D.O. levels. These flows require the use of impounded water to augment the expected summer low flows of 125 cfs desired for recreation enhancement, or even the 200 cfs lows in recent years. Part of these total flows can be provided from the return flows, estimated in Table 11.

Choice b Providing a high degree of secondary treatment (or tertiary treatment) to reduce the stream loading would reduce the required water quality flows approximately in proportion to the reduction in loading.

TABLE 10

REQUIRED STREAM FLOWS TO MAINTAIN WATER QUALITY -

RUSSIAN RIVER

CASE I

(May-November)

Ia. Summer Conditions - All Wastes Returned to the Stream - 5ppm D.O. Level - 25°C

Stream Miles	1960cfs	2010cfs	2060cfs
97-22	15	40	60
22-5.5	55	290	500
5.5-1	85	510	910

(December-April)

Ib. Winter Conditions - All Wastes Returned to the Stream - 7ppm D.O. Level - 13°C

Stream Miles	1960cfs	2010cfs	2060cfs
97-22	10	40	60
22-5.5	45	260	440
5.5-1	65	325	570

CASE II

(May-November)

IIa. Summer Conditions - No Wastes Returned to the Stream from Healdsburg and Downstream-5ppm D.O. Level - 25°C

Stream Miles	1960cfs	2010cfs	2060cfs
97-22	10	35	55
22-5.5	10	35	55
5.5-1	15	55	90

(December-April)

IIb. Winter Conditions - No Wastes Returned to the Stream from Healdsburg and Downstream-7ppm D.O. Level - 13°C

Stream Miles	1960cfs	2010cfs	2060cfs
97-22	10	35	50
22-5.5	10	35	50
5.5-1	20	60	100

TABLE 11

ESTIMATED RETURN FLOWS[a/] - RUSSIAN RIVER

Return Location (River Mile)	1960 Assumed 50% Return, cfs	2010 Assumed 50% Return, cfs	2060 Assumed 50% Return, cfs
Redwood-Potter Valley (94)	--	1.5	3
Ukiah (85)	2	5.5	9
Hopland (65)	--	--	1.5
Cloverdale-Geyserville (46)	--	4.3	7.5
Healdsburg-Santa Rosa-Petaluma-Sebastopol (22)	6.5	44	84
Russian River (10)	--	2.5	5.5

[a/] NOTE: Numbers not reported are below 1 cfs.

Alternative 2 Disposal to land has several variants also. Sewage farms can be developed by the discharger, or treated waste water can be distributed to irrigation users. Developing sewage farms is limited by land costs and application costs, as would be expected. Land disposal may not be a year-around solution as winter rains or frozen soils limit the soil absorption and permeability. Large land areas are also required. Commerical farm irrigation use of treated waste waters is also feasible and would also reduce the total withdrawal for irrigation use from the system. Because part of the treated waste water may not be applied to land, the options of lagooning for carryover storage or disposal to the stream should be considered jointly. Again the quality of treatment becomes a consideration.

Alternative 3 Disposal to the ocean may be possible from several sections, particularly from the Santa Rosa Plains Area and Lower Russian River Area. Ocean disposal of the wastes from the Santa Rosa Area would reduce total waste loads to the river by about 75 percent. Treatment of wastes discharged to the ocean would be necessary and possible discharge locations investigated before any firm recommendations could be made. However, the possibility of ocean disposal for the treated wastes from the Healdsburg, Santa Rosa, Sebastopol, Petaluma Rural and Lower Russian River Areas would reduce the required water quality control flows very substantially. These calculations are shown in Table 10 as Case II. The assumption of direct discharge of wastes generated above Healdsburg to the stream in the summer is not in accordance with present discharge policies, but is used to present a conservative viewpoint.

VII. NEEDS, ALTERNATIVES AND VALUES

This section summarizes and compiles the previous material and considers needs, alternatives and values for:

A) in-basin M & I use

B) water quality control

C) export M & I use

A. In-Basin Municipal and Industrial Use

1. Needs and Alternatives

The data shown in Table 5 indicates that most municipal water supplies rely on ground water. Most ground water sources are located near the river and the good hydraulic connection means that recharge of the ground water basin near the river is continual. The distinction between ground water near the stream and surface water flow is important in a water scarce area, but has not been explored in the Russian River Basin. The State of California Department of Water Resources is compiling data on water appropriations and diversions in the Basin, but this information was not summarized at the time of this report (March 1963).

Analysis of stream flow data for the period 1941-1958 for the station Russian River near Guerneville, shows that the net natural flow past Guerneville, after deducting the water imported from the Eel River, is less than zero for the months of July-September. If this loss can be attributed to consumption, then there is a water use in excess of natural flows during this period. California water rights laws state that imported water shall not be used to satisfy riparian rights. The imported Eel River water is, therefore, satisfying in-basin uses but cannot be considered a substitute for water required to satisfy riparian rights. How much of this use is based on riparian rights is undetermined at present, but the data being gathered by the State should aid in this

determination.

The municipal and industrial water use during the May-November period will be about 70 percent of the annual water use. It is assumed that the quantity of water needed during this period cannot be derived from natural stream flows (an assumption needing further study) and must be derived from the alternative sources of return flows, impounded water, imported water, ground water, or a combination of these sources. In the December-April period the remaining 30% of M & I water use occurs. The natural streamflow is probably adequate to supply all municipal and industrial use during this period.

The estimates of future gross seasonal municipal and industrial needs are shown in Table 12. This table also summarizes some supply alternatives.

2. Values

Detailed information on yields and unit costs of alternative sources for projected municipal and industrial water needs in the Russian River Basin were not available at the time this report was prepared. The contract price for water from the Lake Mendocino-Coyote Dam Project is $7.50 per acre foot. The Corps of Engineers estimated the cost of developing a single purpose water conservation project at the Warm Springs site on Dry Creek, yielding 90,000 acre feet annually, would be $14.00 per acre foot. Preliminary information indicates 75,000 acre feet of additional yield from the second stage of Mendocino-Coyote Dam could be developed at a cost of $4.00 to $6.00 per acre foot. Indications are that costs of other available storage sites would likely exceed costs at the Dry Creek site. On the basis of these costs, it is suggested that an interim average value for future municipal and industrial water supplies in the Russian River Basin of $12.00 per acre foot be used for preliminary planning purposes. This estimate will, of course, be subject to

TABLE 12
PRELIMINARY ESTIMATES OF WATER SUPPLY SOURCES & NEEDS
RUSSIAN RIVER BASIN

		Area	Redwood - Potter Valley	Ukiah	Hopland	Cloverdale--Geyserville	Healdsburg	Santa Rosa	Petaluma Rural	Sebastopol	Russian River Coastal
ALTERNATIVE SOURCES OF WATER (AcFt/yr)	GROUNDWATER a/	Capacity	10,000	75,000	20,000	65,000	70,000	-	1,017,000	-	25,500
		Yield	X	X	X	X	X	X	X	X	X
	IMPOUNDED SURFACE WATER	Present Yield of Upstream b/ Developments	-	60,000	60,000	60,000	150,000	150,000	150,000	150,000	150,000
		Amount of Present Upstream Development Committed to Area c/	-	8,000	-	-	-	14,000	-	250	-
		Estimated Future Yield Developable Upstream From Area d/	53,100	160,600	214,400	266,600	411,600	420,600	420,600	420,600	420,600
	IMPORTS TO BASIN UPSTREAM FROM AREA	Present e/	190,000	190,000	190,000	190,000	190,000	190,000	190,000	190,000	190,000
		Future	X	X	X	X	X	X	X	X	X
FUTURE SEASONAL (MAY-NOV) NEEDS FOR M & I WATER		Need for Impounded Water in Future	likely f/	yes	likely f/	likely f/	yes	yes	yes	yes	yes
		Possible Seasonal Yield Needed g/ Ac.Ft./Season	1000-3000	3000-10,000	600-1700	2000-8000	2000-8000	4000-56,000	600-6000	4000-14,000	700-6000
		Year Storage First Needed	2000	1980	2000	2000	1980	1960	1980	1980	1980

NOTES:
a/ Source: Figure 4, There are no data available on safe groundwater yield.
b/ Coyote Project - Lake Mendocino = 60,000 AF;Dry Creek Project = 90,000 AF
c/ Data from Sonoma County Flood Control and Water Conservation District
d/ Source: Figure 2
e/ Average of present diversion from Eel River to Potter Valley
f/ Depending on three determining factors: cost of surface vs. groundwater, density of population requiring a dependable supply, possible quality difference between surface and ground water.
g/ The seasonal yield is defined as that amount of impounded surface water to be supplied seasonally in excess of possible withdrawal from groundwater or surface water flows during the season or rights to water from these sources. The first number estimated is the seasonal yield required from storage in the first period of need, calculated as the difference between the water use in the first period of need (say year 2000) and the preceding period (say year 1980). The second number is the 2060 seasonal need, calculated as about 70% of the 2060 use.

modification as more detailed information on costs of water from alternate sources become available.

B. Water Quality Control

1. Needs and Alternatives

The estimates for water quality control flows are shown in Table 10. Some alternative means to reduce these flows were discussed in Section VI-D.

A need for water quality control flows will occur in the lower 22 miles of the river beginning around 1990 if all treated wastes are discharged to the stream. Under present conditions, municipal and/or industrial wastes discharged to the Russian River in the summer are significant. Therefore, the assumption of river disposal of all treated wastes is not realistic at present.

A more realistic assumption about future waste flows may be to forecast that the treated wastes from the Santa Rosa Area would not be discharged to the stream. This conjecture is supported by this statement from a consulting engineer:

"This reuse [land disposal] of waste water, combined with possible advancement in technology, could make it possible to dispose of the ultimate waste flow within the Santa Rosa Plain. If a continued waste discharge within the plain is not possible in the future, either the treated or the raw waste would have to be pumped to the ocean for disposal"[5/]

The possibility of disposal other than to the river should be considered. The heavy recreational use of the lower Russian River area means that a high value is attached to the amenities furnished by this area. The present unofficial policy of no direct discharge of treated wastes to the river in the summer months is a result of this concern for water quality. Future waste discharges

from the Santa Rosa area may equal the low flow of the river. At the present time, the downstream summer recreational uses are hindered by flows greater than about 200 cfs. Providing 1000 cfs flows for water quality regulation would make swimming and boating dangerous, but these high flows would be needed to adequately protect water quality with the "all wastes to the stream" discharge condition of Table 10 - Case I.

To protect downstream users, we would have to provide so much water that their benefits would be decreased, not by quality but by the quantity of water. (Lower water temperatures, a consequence of more streamflow regulation, would also affect recreational use).

It appears that there is a potential water resource management conflict since increased streamflow to maintain water quality will possibly decrease "inplace" use as much as lower water quality would. Increased flows would cause an increased probability of drownings, more boating accidents, etc. The land or ocean disposal plan (Section VI-D) would avoid this quality-quantity conflict in the river. Table 10-Case II lists recommended streamflows for the situation where wastes from the lower Russian River - Santa Rosa area are diverted to locations other than the stream.

The potential recreation visitation to the lower Russian River area is forecast as 5 million visitor days/year by 2060 (Appendix A). About 35% of this number or 1.75 million visitor days would be expended in swimming, fishing, and boating. This large usage can be "preserved" by an appropriate disposal plan. A careful economic analysis comparing the costs and benefits may show that some alternative, such as ocean disposal, is best. A model comparing the costs of different alternatives is suggested in Appendix C. A more careful analysis for comprehensive planning could follow the scheme presented in Appendix C.

Because there is no need for water quality control flows at present, and because of the willingness of the Russian River Basin residents to maintain Russian River water quality, there is no forseeable need for water quality control flows in the near future. The longer view on needs for regulation flow would depend upon public policy in the Russian River basin.

It is assumed that the present attitude toward water quality will be maintained in the future. If this is done the streamflow recommendations of Case II in Table 10 should prevail.

The streamflows shown as Case I are not recommended as design guides at this time.

2. Values

The flows recommended in Table 10 - Case II can be satisfied by present and projected future hydrologic conditions. A minimum of 125 cfs flow at Guerneville will be provided in the future as part of the operating schedule of Lake Mendocino (A special Park and Recreation District has been formed for the Lower Russian River Area which assesses property owners in the area to pay a part of the costs of providing this minimum flow). Because there is no need under Case II conditions, there is no forseeable value to be claimed at present for storage for water quality flow regulation.

C. Potential Out-Basin Municipal and Industrial Uses - Export Market for Russian River Water.

1. Needs and Alternatives

As shown in Figure 5, and Table 6, there are two existing service areas for Russian River water outside the drainage basin (in Marin and Sonoma Counties) and a potential third area in the Napa Valley which includes parts of Napa and

Solano Counties. These service areas and their supply alternatives are diagrammed in Table 13 and Table 14.

The supply figures for in-basin surface water developments are based on estimates by the State of California Department of Water Resources[6/] and a consulting engineering firm.[7/] An arbitrary limit of $60 per acre-foot as a maximum price for developing in-basin water sources was used, as this appears to be the maximum cost of equivalent quality imported water.

The present importation of Russian River water by Sonoma and Marin areas is based on contracts and aqueducts completed since 1960. Based upon the supply and use estimates of Table 14, it appears that additional water will be needed in the area by about 1980. The decision by Marin County between North Bay Aqueduct or Russian River water is uncertain at present.

The Sonoma area is presently supplied with Russian River water through aqueducts to Petaluma and Sonoma. Based on Table 14, it appears that this area will need additional water supplies by 1980. The choice is again between Russian River and North Bay Aqueduct water. Conversations with the State Department of Water Resources and the Sonoma County Flood Control District indicate that there may be an equal cost aqueduct parallel to and near the Petaluma-Sonoma axis for delivered water of comparable quality from the Russian River or North Bay Aqueduct.

In addition to municipal and industrial use, Russian River water could be used for water quality control in the Napa River. The need for quality control in this basin has not been determined but, based on discussions with the San Francisco Bay Regional Water Pollution Control Board, there may be a need in the near future for quality regulation flows in the Napa River.

2. Values

The choice between alternative sources of water is dependent on costs, dependability of supply, and quality of supply. The most likely alternative to

Russian River water as a source of municipal and industrial supply is the State of California's proposed North Bay Aqueduct which would divert water from Lindsey Slough, a tributary of the Sacramento-San Joaquin Rivers Delta in Solano County. The California Department of Water Resources[6/] has estimated the canal-side price for raw water per acre-foot delivered through the North Bay Aqueduct as follows:

Solano County	$ 8.10-10.00
Napa County	$ 16.60-20.40
Sonoma County	$ 21.90-27.10
Marin County	$ 25.40-35.50

The price ranges result from different aqueduct carrying capacities ranging from 55,000 to 242,000 acre feet per year. The quality of water from this source would be lower than that from the Russian River. However, these costs are considered appropriate for evaluating future municipal and industrial water benefits in the export areas at this time. Based on the ultimate needs of each area (Table 14) and the above price schedule it is estimated that benefits per acre-foot of water delivered to the export areas would be as follows:

Napa Valley and Vallejo	$19.00
Sonoma County	$27.00
Marin County	$29.00

TABLE 13

ALTERNATIVE SUPPLY SOURCES - PRESENT AND FUTURE OUTSIDE OF THE RUSSIAN RIVER BASIN

Supply Source	Area		
	Sonoma Creek Basin	Marin County	Napa Valley & Vallejo
In-basin sources	(a) Estimated water conservation yield of developable surface water 1,200 Ac.Ft. a/ (b) Present ground water pumping - 4,460 Ac.Ft. a/	(a) Yield of developed surface water - 30,800 Ac.Ft.	(a) Presently developed surface water yield is 19,000 Ac.Ft. a/Future developable surface water costing less than $60/A.F. is about 21,380 Ac.Ft. b/ (b) Estimate of ground water yield - 25,000 Ac.Ft. b/
Russian River Water	Sonoma City & Valley of the Moon Water District have contracted for 3,500 Ac.Ft. Petaluma City has contracted for 4,500 Ac.Ft.	North Marin MUD has a contract for 10,000 Ac. Ft. with completed Aqueduct to Novato	Possible, with Knight's Valley Diversion Project.
North Bay Aqueduct California Dept. of Water Resources	Possible, contract negotiation underway, deadline of 12/31/63 for commitment.	Possible, contract negotiation underway, deadline of 12/31/63 for commitment.	Possible, contract negotiation underway, deadline of 12/31/63 for commitment. Existing supply for Vallejo comes from Cache Slough, a supply system comparable to the North Bay Aqueduct.
U.S. Bureau of Reclamation	Not likely.	Not likely.	Possible, via Lake Berryessa & Putah Creek system.

Sources: a/ State of California, Dept. of Water Resources, Bull. No. 110 "North Bay Aqueduct," December 1961, Sacramento, California.
b/ Farnum Kerr Assoc.-Frederick Holes Planners, Civil Engineers, "Napa County Water Needs Study and Plan." Prepared for Napa County Flood Control and Water Conservation District, Napa County, California.

TABLE 14

SUMMARY OF SUPPLY AND USE OUTSIDE OF THE RUSSIAN RIVER BASIN

(Acre Feet)

	Sonoma Creek Basin	Marin County	Napa Valley	
Supply Source				
In-basin Groundwater	4,460	--	25,000	
In-basin Surface Water	1,200	30,800	40,380	
Committed Imports	8,000	10,000	--	
Total Supply	13,660	40,800	65,380	
Use Projection			Without Vallejo	With Vallejo
1980	17,120	42,540	18,500	38,700
2000	42,450	72,190	31,400	65,100
2020	81,400	154,530	56,200	116,300
2040	110,280	188,680	73,200	159,800
2060	123,450	218,490	86,000	194,000
Probable Year of Need	1980	1980	2040	2000

VIII. BIBLIOGRAPHY

1. U. S. Army Corps of Engineers "Interim Report for Flood Control and Allied Purposes, Russian River, California, Dry Creek Basin," October 1961, Appendix A, pp. A-2.

2. ibid. (see above) pp. A-4.

3. ibid. (see above) pp. A-5.

4. U. S. Army Corps of Engineers, San Francisco District, "Economic Base for Future Development of the Russian River Basin" 1962.

5. Yoder, M. Carleton, Consulting Engineer "Collection, Treatment, and Disposal of Sewage and Industrial Wastes Within the Santa Rosa Plain" Report to County of Sonoma, Sonoma County, California July, 1962.

6. State of California, Department of Water Resources Bulletin No. 110, "North Bay Aqueduct," December 1961, Sacramento, California.

7. Farnum Kerr Associates - Frederick Hotes Planners, Civil Engineers, "Napa County Water Needs Study and Plan," prepared for Napa County Flood Control and Water Conservation District, Napa County, California. 1961.

APPENDIX A

WATER USE PROJECTIONS

The purpose of this section is to describe in a step-by-step manner the computational procedure used in obtaining the water use projections. In addition all of the assumptions underlying the computational procedure will be enumerated.

Two separate types of gross water use projections were made for the Russian River Study: within the Basin use, including parts of Sonoma and Mendocino Counties, and use outside of the Basin in potential water market areas such as Marin, Sonoma and Napa Counties. The within-basin use was computed in a more detailed fashion because more data were available.

A. In-basin Projections

To facilitate the study the Russian River Basin was divided into sub-areas, first by county and then by census division. Each sub-area then represented an economic unit based on a community or center of population. Economic base data were furnished by the Corps for each sub-area. These data included projections of land use, population, employment and recreation use.

Water use within each economic unit was broken down into five separate categories. In this way the future water use projections could be made based on growth in various sectors of the economy. To test the reasonableness of this approach the water use computed for the year 1960 was compared with actual reported usage published by the State Health Department[a/] and the Public Health Service.[b/] Base data for industrial water use were obtained from a

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a/ State of California, Department of Public Health, "California Domestic Water Supply Statistics," 1958.

b/ U. S. Department of Health, Education, and Welfare, Public Health Service, "Municipal Water Facilities Inventory as of Jan. 1, 1958," Vol. 9.

Department of Commerce report[a/] and the projections made accordingly.

The following example demonstrates the actual computations of water use for the year 2060 for the Santa Rosa area:

Heavy water using industry	
Water use per employee (2,020 gpd)	
X number of employees (3,600)	= 7,272,000
+	
Light water using industry	
Water use per employee (120 gpd)	
X number of employees (32,000)	= 3,840,000
+	
Water use for service employee	
Water use per employee (20 gpd)	
X number of employees (139,380)	= 2,787,000
+	
Water use for visitors	
Water use per visitor (20 gpd)	
X number of visitors (3,650)	= 73,000
+	
Residential water use	
Water use per resident (120 gpd)	
X number of residents (442,000)	= 53,040,000

Summing up and changing to acre-feet gives water use per year = (67,012,600) (0.00112) = 75,040 acre-feet.

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a/ U. S. Department of Commerce, Bureau of the Census, "Industrial Water Use, 1958 Census of Manufacturers," No. MC58(1) - 11.

The basic data for making the water use projections are shown in Table A-1 and Table A-2.

Numbers for the input data were furnished by the Corps and were used according to the following definitions:

1. Industrial Employment

Total industrial employment was divided into two categories, heavy and light water using industry. The divisions were made according to the percentages shown below:

	Percent	
Mendocino County	Heavy	Light
Redwood-Potter Valley	10	90
Ukiah	33.3	66.7
Hopland	10	90
Sonoma County		
Cloverdale-Geyserville	25	75
Healdsburg	5	95
Santa Rosa	Increase by 600 employees per year	The remainder
Petaluma	15	85
Sebastopol	Increase by 150 employees per year	The remainder
Russian River	5	95

2. Service Employment

These employment data are listed as "other" in the Corps projections. Total employment projections are shown in Table A-3.

TABLE A-1

POPULATION INPUT VECTORS - RUSSIAN RIVER BASIN

	1960	1980	2000	2020	2040	2060
	Cloverdale - Geyserville					
Heavy Industry	280	500	650	950	1,110	1,220
Light Industry	830	1,480	1,960	2,830	3,330	3,670
Service	660	2,990	4,370	6,800	10,850	12,500
Visitors	100	1,380	1,780	2,600	4,250	5,950
Residents	7,900	16,000	21,000	32,000	44,000	50,000
	Healdsburg					
Heavy Industry	120	180	220	270	300	310
Light Industry	2,260	3,300	4,200	4,980	5,570	5,840
Service	990	2,000	3,470	10,280	14,370	16,610
Visitors	40	230	330	680	1,140	2,950
Residents	11,500	18,000	24,000	44,000	56,000	63,000
	Santa Rosa					
Heavy Industry	600	1,200	1,800	2,400	3,000	3,600
Light Industry	1,630	6,480	11,380	20,690	27,510	32,000
Service	13,200	35,700	58,420	95,680	122,530	139,380
Visitors	110	680	1,310	1,710	2,770	3.650
Residents	46,900	119,000	192,000	308,000	391,000	442,000
	Petaluma					
Heavy Industry	30	60	100	260	440	570
Light Industry	170	340	560	1,470	2,470	3,210
Service	130	760	1,620	5,440	9,290	12,380
Visitors	30	150	170	200	300	690
Residents	2,600	5,000	8,000	22,000	35,000	45,000
	Sebastopol					
Heavy Industry	250	400	550	700	850	1,000
Light Industry	700	1,900	3,010	5,340	6,770	8,040
Service	1,220	6,100	11,330	19,480	25,910	31,110
Visitors	5	15	15	30	350	690
Residents	11,800	30,000	48,000	76,000	97,000	113,000

TABLE A-1 (Cont'd)

	1960	1980	2000	2020	2040	2060
	Russian River					
Heavy Industry	10	15	25	45	65	100
Light Industry	230	305	475	865	1,215	1,900
Service	1,910	2,930	4,760	9,260	11,700	13,580
Visitors	230	1,000	1,570	4,260	7,290	9,380
Residents	7,700	11,000	17,000	31,000	39,000	46,000
	Redwood - Potter Valley					
Heavy Industry	40	70	90	130	160	190
Light Industry	390	620	850	1,180	1,500	1,660
Service	850	1,690	2,530	3,670	5,220	6,180
Visitors	100	460	700	1,200	2,020	2,920
Residents	4,400	7,000	10,000	15,000	20,000	23,000
	Ukiah					
Heavy Industry	470	690	790	1,090	1,340	1,430
Light Industry	930	1,370	1,590	2,190	2,700	2,860
Service	3,880	6,520	8,110	11,610	15,370	17,130
Visitors	470	1,320	1,600	2,330	3,800	5,500
Residents	12,600	26,000	31,000	43,000	55,000	59,000
	Hopland					
Heavy Industry	30	40	60	70	80	90
Light Industry	260	350	500	640	700	770
Service	50	620	1,250	2,100	2,830	3,550
Visitors	130	640	1,290	2,030	3,390	4,740
Residents	1,600	4,000	6,000	9,000	11,000	13,000

TABLE A-2

UNIT WATER USES - RUSSIAN RIVER

Use in Gallons Per Day

User	Heavy Water Use Industry	Light Water Use Industry	Service	Visitor	Residents
Industrial & Service	2,000	100	0	10	10
Sanitation & Domestic	20	20	20	10	See Table Below

RESIDENT WATER USE - SANITATION & DOMESTIC

Area	1960	1980	2000	2020	2040	2060
Cloverdale-Geyserville	80	100	120	120	120	120
Healdsburg	60	90	120	120	120	120
Santa Rosa	60	90	120	120	120	120
Petaluma	60	90	120	120	120	120
Sebastopol	100	120	120	120	120	120
Russian River	80	100	120	120	120	120
Redwood-Potter Valley	80	100	120	120	120	120
Ukiah	100	120	120	120	120	120
Hopland	80	100	120	120	120	120

TABLE A-3

EMPLOYMENT BY MAJOR CATEGORIES - RUSSIAN RIVER BASIN

	1960	1980	2000	2020	2040	2060
Ukiah & Ukiah Rural						
Total Employment	5,500	8,800	10,700	15,100	19,600	21,600
Agriculture	220	220	210	210	190	180
Industry a/	1,400	2,060	2,380	3,280	4,040	4,290
Other	3,880	6,520	8,110	11,610	15,370	17,130
Redwood-Potter Valley						
Total Employment	1,400	2,500	3,590	5,100	7,000	8,150
Agriculture	120	120	120	120	120	120
Industry a/	430	690	940	1,310	1,660	1,850
Other	850	1,690	2,530	3,670	5,220	6,180
Hopland						
Total Employment	490	1,160	1,960	2,960	3,760	4,560
Agriculture	150	150	150	150	150	150
Industry a/	290	390	560	710	780	860
Other	50	620	1,250	2,100	2,830	3,550
Santa Rosa Complex						
Total Employment	16,400	44,300	72,400	119,500	153,700	175,600
Agriculture	970	920	800	730	660	620
Industry a/	2,230	7,680	13,180	23,090	30,510	35,600
Other	13,200	35,700	58,420	95,680	122,530	139,380
Petaluma Rural						
Total Employment	800	1,600	2,700	7,500	12,500	16,400
Agriculture	470	440	420	330	300	240
Industry a/	200	400	660	1,730	2,910	3,780
Other	130	760	1,620	5,440	9,290	12,380
Sebastopol						
Total Employment	3,800	9,900	16,300	26,800	34,700	41,200
Agriculture	1,630	1,500	1,410	1,280	1,170	1,050
Industry a/	950	2,300	3,560	6,040	7,620	9,040
Other	1,220	6,100	11,330	19,480	25,910	31,110

(continued..)

TABLE A-3 (Cont'd)

	1960	1980	2000	2020	2040	2060
Healdsburg						
Total Employment	3,800	5,900	8,300	15,900	20,600	23,100
Agriculture	430	420	410	370	360	340
Industry a/	2,380	3,480	4,420	5,250	5,870	6,150
Other	990	2,000	3,470	10,280	14,370	16,610
Cloverdale-Geyserville						
Total Employment	2,000	5,200	7,200	10,800	15,500	17,600
Agriculture	230	230	220	220	210	210
Industry a/	1,110	1,980	2,610	3,780	4,440	4,890
Other	660	2,990	4,370	6,800	10,850	12,500
Russian River Coastal						
Total Employment	2,300	3,400	5,400	10,300	13,100	15,700
Agriculture	150	150	140	130	120	120
Industry a/	240	320	500	910	1,280	2,000
Other	1,910	2,930	4,760	9,260	11,700	13,500

a/ Includes heavy industry

3. Visitors

Data on numbers of visitors are shown in Table A-4. Distribution of visitors was done on the basis of recreational land available. The distribution factor, f, is computed by the following equation:

$$f = 0.5 \frac{\text{Acres of public and reserved land in census division}}{\text{Total acres of public and reserved land}} + 0.5 \frac{\text{Acres unreserved and undeveloped land in census division}}{\text{Total acres of unreserved and undeveloped land}}$$

Recreation distribution factors are shown in Table A-5.

4. Numbers of Residents

These numbers were obtained from population forecasts shown in Table A-6.

B. Outside-the-Basin Water Use

The Corps requested water use projections for three potential service areas outside the Basin. These areas include Marin County, other areas of Sonoma County, and Napa County including the Vallejo complex (which is in Solano County). The water use projections were made by assuming a gross per capita water use (including Municipal and Industrial) which was multiplied by the Population Projections which were furnished by the Corps. Tables A-7 and A-8 and A-9 show data used for the calculations and the projections.

TABLE A-4

RECREATION USE - RUSSIAN RIVER BASIN[a/]

(Visitor Days)

Year	From Outside of Russian River Basin	Residents of Russian River Basin	Total
1960	450,000	300,000	750,000
1980	2,140,000	1,260,000	3,400,000
2000	3,210,000	1,890,000	5,100,000
2020	5,500,000	3,230,000	8,730,000
2040	9,240,000	5,160,000	14,400,000
2060	13,300,000	6,900,000	20,200,000

It is expected that the total recreation use will be divided into the several categories of activity as follows:

Activity	Percent of Total	Activity	Percent of Total
Swimming	16	Picknicking	9
Fishing	10	Riding & Hiking	1
Camping	20	Hunting	2
Boating	11	Community Activities	31

a/ Source: U. S. Army Corps of Engineers (Revision of Feb., 1963)

TABLE A-5

VISITOR DISTRIBUTION FACTORS FOR RUSSIAN RIVER

Census Division	1960	1980	2000	2020	2040	2060
Redwood	0.077	0.079	0.080	0.080	0.080	0.080
Ukiah	0.383	0.224	0.185	0.155	0.150	0.151
Hopland	0.106	0.109	0.147	0.135	0.134	0.130
Cloverdale	0.086	0.235	0.202	0.173	0.168	0.163
Healdsburg	0.033	0.039	0.038	0.045	0.045	0.081
Santa Rosa	0.092	0.116	0.149	0.114	0.109	0.100
Petaluma	0.030	0.025	0.019	0.013	0.012	0.019
Sebastopol	0.003	0.003	0.002	0.002	0.014	0.019
Russian River	0.190	0.170	0.178	0.283	0.288	0.257

TABLE A-6

POPULATION PROJECTIONS, 1960 - 2060 - RUSSIAN RIVER BASIN

(Shown by Census Divisions)

County and Census Division a/	1960 b/	1980	2000	2020	2040	2060
Mendocino County:						
Redwood-Potter Valley	4,400	7,000	10,000	15,000	20,000	23,000
Ukiah & Ukiah Rural - Talmage	12,600	26,000	31,000	43,000	55,000	59,000
Hopland	1,600	4,000	6,000	9,000	11,000	13,000
Sonoma County:						
Cloverdale - Geyserville	7,900	16,000	21,000	32,000	44,000	50,000
Healdsburg	11,500	18,000	24,000	44,000	56,000	63,000
Santa Rosa Complex c/	46,900	119,000	192,000	308,000	391,000	442,000
Petaluma Rural c/	2,600	5,000	8,000	22,000	35,000	45,000
Sebastopol	11,800	30,000	48,000	76,000	97,000	113,000
Russian River	7,700	11,000	17,000	31,000	39,000	46,000
Basin Total	107,000	236,000	357,000	580,000	748,000	854,000

a/ U. S. Census Bureau "Census Divisions" as shown in 1960 Census of Population. The following census divisions are bisected by the basin boundaries: Redwood-Potter Valley, Hopland, Russian River Coastal, Petaluma Rural & Sebastopol.

b/ Estimate Based on 1960 Census of Population.

c/ Combining census divisions of Santa Rosa, Santa Rosa North & South Park.

d/ Does not include the City of Petaluma.

TABLE A-7

WATER USE - OUTSIDE OF RUSSIAN RIVER BASIN

(Calculations)

MARIN COUNTY

	1960	1980	2000	2020	2040	2060
	Novato Area					
Population	21,700	53,200	94,700	274,400	319,600	375,600
Water Use, gpcd	140	150	160	170	170	170
Water Use, AF/Yr.	3,400	8,940	17,000	52,000	60,700	71,400
	North Coastal Area					
Population	1,500	2,100	2,700	8,000	12,000	16,000
Water Use, gpcd	100	110	120	130	140	150
Water Use, AF/Yr.	170	260	360	1,160	1,880	2,690
	San Rafael, Lucas-Gallinas Valley, Ross Valley					
Population	82,900	108,200	155,200	344,300	429,300	486,300
Water Use, gpcd	150	160	170	170	170	170
Water Use, AF/Yr.	13,900	19,400	29,600	65,600	81,700	92,500
	Mill Valley, Sausalito and Tiburon					
Population	36,200	76,700	130,800	165,400	195,900	225,900
Water Use, gpcd	140	150	160	170	170	170
Water Use, AF/Yr.	5,670	12,900	23,400	31,200	37,200	43,000
	San Geronimo Valley					
Population	2,100	6,200	10,200	24,000	37,800	46,700
Water Use, gpcd	140	150	160	170	170	170
Water Use, AF/Yr.	330	1,040	1,830	4,570	7,200	8,900

TABLE A-8

WATER USE-OUTSIDE OF RUSSIAN RIVER BASIN

(Calculations)

NAPA RIVER BASIN

	1960	1980	2000	2020	2040	2060
Napa Basin Without Vallejo						
Population	57,280	110,000	175,000	295,000	385,000	450,000
Water Use, gpcd	140	150	160	170	170	170
Water Use AF/Yr.	9,000	48,500	31,400	56,200	73,200	86,000
Vallejo Complex						
Population	74,390	150,000	215,000	335,000	455,000	565,000
Water Use, gpcd	100	120	140	160	170	170
Water Use AF/Yr.	8,320	20,200	33,700	60,100	86,600	108,000

TABLE A-9

WATER USE-OUTSIDE OF RUSSIAN RIVER BASIN

(Calculations)

SONOMA COUNTY

	1960	1980	2000	2020	2040	2060
Petaluma Census Division						
Population	27,000	51,000	143,000	292,000	394,000	450,000
Water Use, gpcd	100	120	140	160	170	170
Water Use AF/Yr.	3,020	6,850	22,400	52,300	75,000	85,600
Sonoma (Sonoma Creek Basin)						
Population	23,400	68,000	106,500	134,000	151,000	162,000
Water Use gpcd	100	120	140	160	170	170
Water Use AF/Yr.	2,620	9,130	16,600	24,000	28,800	30,800
Santa Rosa North (Sonoma Creek Basin)						
Population	1,300	8,500	22,000	28,500	34,000	37,000
Water Use gpcd	100	120	140	160	170	170
Water Use AF/Yr.	150	1,140	3,450	5,100	6,480	7,050

APPENDIX B

QUALITY REGULATION FLOW CALCULATIONS

The procedure for calculating flows for quality control regulation is based primarily on applying the "oxygen-sag" equation. The classical "oxygen-sag" equation is:

$$D_t = L_a \left(\frac{k_1}{k_2 - k_1} \right) (e^{-k_1 t} - e^{-k_2 t}) + D_a e^{-k_2 t}$$

where:

D_t = the oxygen deficit in the stream at time t

L_a = first-stage BOD

k_1 = deoxygenation constant

k_2 = reaeration constant

D_a = the initial oxygen deficit at time t = 0

t = time in days

L_a is calculated by multiplying a coefficient matrix expressed in population equivalents by a column vector representing the user population inputs. The resulting product matrix then is multiplied by a unit pollution load equivalent. This transformation results in obtaining the total pollution load per day that would reach the stream if no treatment were provided. This report assumes that the waste treatment efficiency for the Russian River Basin is 90 percent. Therefore, the pollution load assumed to enter the stream (L_a) after treatment is equal to 10 percent of the total pollution load without treatment.

The previous steps are summarized in the following example:

Population Equivalents per Unit Input

Category	Heavy Industry	Light Industry	Service	Visitors	Residents
Industry Service	30	1	0	0.1	0.1
Sanitation & Domestic	0.1	0.1	0.1	0.1	1.0

(Constant coefficient matrix for period 1960 - 2060)

L_a = [Industry Service / Sanitation & Domestic] X

	2060 Input vector for Ukiah
Heavy Industry	1,430
Light Industry	2,860
Service	17,130
Visitors	5,500
Residents	59,000

X 0.30 X .10 (2060 Unit Pollution load equivalent; 1-treatment efficiency)

$L_{a\ \text{Ukiah 2060}}$ = 3,420 Lbs BOD/Day

L_a for each sub-area within the Basin is calculated in a similar fashion. Table 9 in the main body of the report presents the computed L_a values. Table A-1 shows input vectors for each sub-area in the Basin.

The total pollution load from each sub-area is assumed to be discharged at a specific mile point on the Russian River. Table B-1 shows the waste discharge locations assigned to each sub-area.

The unit pollution load equivalent is expressed as pounds of first stage BOD per day per population equivalent. The 1960 value of the unit pollution equivalent was estimated to be 0.24. A trend factor was applied to this value to bring the 2010 and 2060 unit pollution load equivalent to 0.30.

TABLE B-1

POLLUTION LOAD DISCHARGE LOCATIONS ON RUSSIAN RIVER

Basin Sub-Area	Discharge Point (River Mile)
Redwood-Potter Valley	94
Ukiah	85
Hopland	65
Cloverdale - Geyserville	46
Healdsburg	22
Santa Rosa	22
Petaluma	22
Sebastopol	22
Lower Russian River	22

Several design conditions were used, with variation in water temperature, and variations in waste loadings discharged to the stream. As presented in Table 10 of the main report, there were two discharge conditions and two temperature conditions, resulting in four patterns of flow requirement. These were presented as Case I - Summer and Winter Conditions and Case II - Summer and Winter Conditions. Case I assumed all wastes would be discharged to the stream, Case II assumed only a portion of the wastes would be discharged to the stream (those generated above Healdsburg).

The case II assumption results in much lower flows, as shown in Table 10.

The two temperatures established for design were 25°C (summer) and 13°C (winter).

k_1 was assumed to be 0.29 @ 25°C and 0.149 @ 13°C (base e).

k_2 was calculated by Churchill's equation[a/] for three specific reaches of the Russian River. Table B-2 shows the specific reaches of the stream with their corresponding k_2 values. All k_2 values are to the base e and were calculated for a stream temperature of 25°C and 13°C.

D_a, the initial oxygen deficit, was assumed to be zero at the head waters of the Russian River. Each waste load contributes an initial deficit estimated as 0.2 of the discharge BOD.

The time that the pollution load remains in the stream is of prime importance. This time is dependent upon the velocity of the stream. Knowing the velocity of specific reaches, the total oxygen deficiency per day due to the biochemical oxygen demand of the waste can be calculated for any mile point in question. Stream velocities are presented in Table B-3.

D_t, the oxygen deficit in the stream at time "t" was calculated for all loads passing at mile points 85, 65, 46, 22, 14, 5.5, and 1. The accumulated oxygen deficits in the Russian River at the above mile points are shown in Table B-4.

Quality control flows are determined from a linear relationship which

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a/ M.A. Churchill, H. L. Elmore and R.A. Buckingham "The Prediction of Stream Reaeration Rates," Journal of the Sanitary Engineering Division, Proceedings of the American Society of Civil Engineers, July 1962, Vol. 88, No. SA4, Paper No. 3199.

TABLE B-2

REAERATION COEFFICIENTS FOR RUSSIAN RIVER

Reach of Stream in Miles	k_2 (to base e) 25°C	13°C
97 - 22	3.12	2.34
22 - 5.5	1.04	0.78
5.5 - 0	0.26	0.195

TABLE B-3

STREAM VELOCITIES FOR RUSSIAN RIVER

Reach of Stream in Miles	Velocity (miles/day) Q = 700 cfs	Q = 170 cfs
97 - 22	51.0	28.0
22 - 5.5	16.4	8.0
5.5 - 0	4.5	2.0

TABLE B-4

ACCUMULATED DISSOLVED OXYGEN DEFICITS IN RUSSIAN RIVER (lbs O_2 deficit/day)

Case I - (all wastes - 700 cfs streamflow)

Mile Points Russian River	Summer Deficits-25°C			Winter Deficits-13°C		
	1960	2010	2060	1960	2010	2060
94	32	116	204	32	116	204
85	166	529	838	166	531	839
65	115	389	632	113	384	619
46	175	628	964	167	604	923
22	726	4167	6871	715	4126	679
14	867	4680	8050	735	4170	7120
5.5	877	4590	8060	600	3400	4890
1	1379	8200	14,640	975	5200	9170

Case II- (wastes from above Healdsburg only - 170 cfs streamflow)

Mile Points Russian River	Summer Deficits-25°C			Winter Deficits-13°C		
	1960	2010	2060	1960	2010	2060
94	32	116	204	32	116	204
85	162	514	811	162	513	812
65	93	31	517	86	294	480
46	155	561	854	145	534	811
22	90	319	532	81	287	470
14	159	561	942	139	485	811
5.5	151	532	896	152	531	890
1	243	846	1430	236	962	1615

incorporates an assumed quality parameter. The quality parameter used in our computations is an allowable dissolved oxygen deficit. The allowable dissolved oxygen deficit was made equal to 3 ppm (to maintain 5 ppm DO in the summer and 7 ppm in the winter). The linear relationship is developed as follows:

$$\frac{\text{Deficit (lbs/day)}}{\text{Water required (lbs/day)}} = .000003$$

$$\text{Water required per day} = \frac{\text{Deficit}}{(.000003)}$$

$$\frac{\text{ft}^3}{\text{sec}} \times 86{,}400 \frac{\text{sec}}{\text{day}} \times 62.4 \frac{\text{lbs}}{\text{ft}^3} = \frac{\text{lbs}}{\text{day}} \times \frac{1}{(.000003)}$$

$$\text{cfs} = .0618 \text{ Deficit (lbs)}$$

The total oxygen deficits of each mile point are converted to quality control flows by the above factor (.0618).

Table 10 shows the required minimum flows necessary for quality control regulation.

APPENDIX C

CASE EXAMPLE FOR COMPARISON OF WASTE DISPOSAL ALTERNATIVES

The objective of this section is to develop a measure of water used and associated costs to maintain a given water quality objective in the Russian River below the Santa Rosa Plains through the year 2060.

The study area for pollution generation, i.e., the origin of waste and return flows, are these areas in the Russian River Basin:

1. Santa Rosa
2. Healdsburg
3. Sebastopol
4. Petaluma Rural

The example year is 2060. The return flows from the example area are estimated at 50 percent of total water use in 2060. It is assumed that the treatment efficiency is 90 percent. The quality design parameter is a maximum allowable dissolved oxygen deficit of 3 ppm.

The disposal alternatives considered are:

1. Normal secondary treatment - river disposal (90%).
2. High degree of secondary treatment - river disposal (95%).
3. Land disposal to irrigation during 4-1/2 month growing season - river disposal remainder of year.
4. Ocean disposal.

The in-basin water uses were then calculated from the following procedures:

DISPOSAL ALTERNATIVE - 6 MONTH CRITICAL PERIOD

User	River Disposal: Secondary Treatment	River Disposal: Tertiary Treatment	Land Disposal	Ocean Outfall
M & I	X_1	X_1	X_1	X_1
Recreation	R	R	R	R
Irrigation	Z	Z	$Z - .75\ X_2$	Z
Quality Control	$Y - X_2 - R$	$2/3Y - X_2 - R$	$.25\ (Y - X_2 - R)$	0

Where, X_1 = Season Water Use = 0.7 (2060 M&I Water Use) = 84,000 Acre-Feet/Season,

X_2 = Return Flow = 0.5 X_1,

R = Recreation Use requirement at 125 cfs - 13,000 Acre-Feet/Season,

Z = Irrigation Use 5 30 Acres @ 2.5 Acre-Feet = 125,000 Acre-Feet/Season,

Y = Gross Quality Flows in 2060 = 186,000 Acre-Feet/Season (for the example area, assuming all 90% treated wastes are returned to the stream).

The calculating procedure is intended only as an example of the approach that would be used to examine alternative disposal proposals.

Combining the equations with the numbers shown above, we get the results of Table C-1.

Cost estimates for the various alternatives are based on the following assumptions:

1. Cost of water = $10/Acre-Foot
2. ENR Construction cost index is 1,000
3. Treatment of disposal project life is 50 years, discount rate is 3 percent.

TABLE C-1

IN-BASIN WATER USE TO MAINTAIN STATED WATER QUALITY OBJECTIVES

AS A FUNCTION OF METHOD OF DISPOSAL OF TREATED SEWAGE

SANTA ROSA PLAINS - YEAR 2060

(Water Use Figures in 1,000's of Acre-Feet)

	Disposal Alternative			
User	(a) River Disposal Normal Treatment	(b) River Disposal Tertiary Treatment	(c) Land Disposal	(d) Ocean Outfall
M & I	84	84	84	84
Recreation	13	13	13	13
Irrigation	125	125	94	125
Water Quality	131	69	33	0
Total Water Use	353	291	224	222

4. The specific treatment cost estimates are based on consulting engineers' cost estimates: Brown & Caldwell, and M. Carelton Yoder, which are available to this office.

The particular cost estimates that resulted are shown in Table C-2. The numbers generated in Table C-2 are only approximate and could vary substantially with careful estimating.

The interpretation of the numbers in row (7) "Cost Difference - 6(a) - Others" is that this number represents the initial cost saving of this alternative over secondary treatment - river disposal. The cost saving shown is the limiting amount that could be expended per year for the alternative treatment method and still have a cost less than the secondary treatment - river disposal.

Row (8) shows an estimated unit cost for additional treatment or disposal. Comparing this row with row (7) shows that this cost is less than the cost saving for the two alternatives - land disposal and ocean disposal. This means that these alternatives are feasible.

Row (9) shows the net cost saving of each alternative.

A cost saving to cost of saving computation can be made by comparing row (7) and row (8). This is shown in Table C-3 as row (a).

The cost of saving water, per acre-foot of water saved can be calculated by dividing row (8), Additional Cost of Treatment or Disposal of Table C-2, by row (b), Water Saved of Table C-3, to get row (c) of Table C-3.

This number shown in row (c) as the "Cost of Water Saved" forms an alternative cost to providing quality control flow. This number is the alternative cost avoided by flow augmentation.

Each disposal alternative provides the same benefits to the users, i.e., meeting water requirements for M&I, Recreation, and Irrigation use, and

TABLE C-2

COST ESTIMATES FOR WATER USE AND WASTE TREATMENT OR DISPOSAL

SANTA ROSA PLAINS - YEAR 206C

(In 1000s of Dollars/Year)

Cost Category	Disposal Alternative (a) River Disposal Secondary Treatment	(b) River Disposal Tertiary Treatment	(c) Land Disposal	(d) Ocean Outfall
(1) M&I Use	840	840	840	840
(2) Recreation Use	130	130	130	130
(3) Irrigation Use	1,250	1,250	940	1,250
(4) Quality Control	1,310	690	330	0
(5) Secondary Treatment/ Year	1,425	1,425	1,425	1,115
(6) Sub-Total	4,955	4,335	3,665	3,335
(7) Cost Difference (6(a) - Others	--	620	1,290	1,620
(8) Additional Cost of Treatment or Disposal/Year	--	1,000	250	1,600
(9) Net Cost Saving (7)-(8)	--	(-380)	1,040	20

TABLE C-3

BENEFIT AND COST COMPARISONS

SANTA ROSA PLAINS - YEAR 2020

Row	Item	Disposal Alternatives (a) River Disposal Secondary Treatment	(b) River Disposal Tertiary Treatment	(c) Land Disposal	(d) Ocean Outfall
(a)	Ratio, $\frac{\text{Cost Saving}}{\text{Cost of Saving}}$	--	.62	5.16	1.01
(b)	Water saved (ac.ft.)	--	62,000	129,000	131,000
(c)	"Cost" of water saved	($10.00)	$16.15	$1.94	$12.20
(d)	Ratio, Water @ $10/ac.ft. [a/]	1.00	.88	1.36	1.01
(e)	Ratio, Water @ $5/ac.ft. [a/]	1.00	.75	1.13	.77
(f)	Ratio, Water @ $20/ac.ft. [a/]	1.00	1.06	1.73	1.49

a/ B/C ratio @ B = Cost of Sec. Treat. & River Disposal

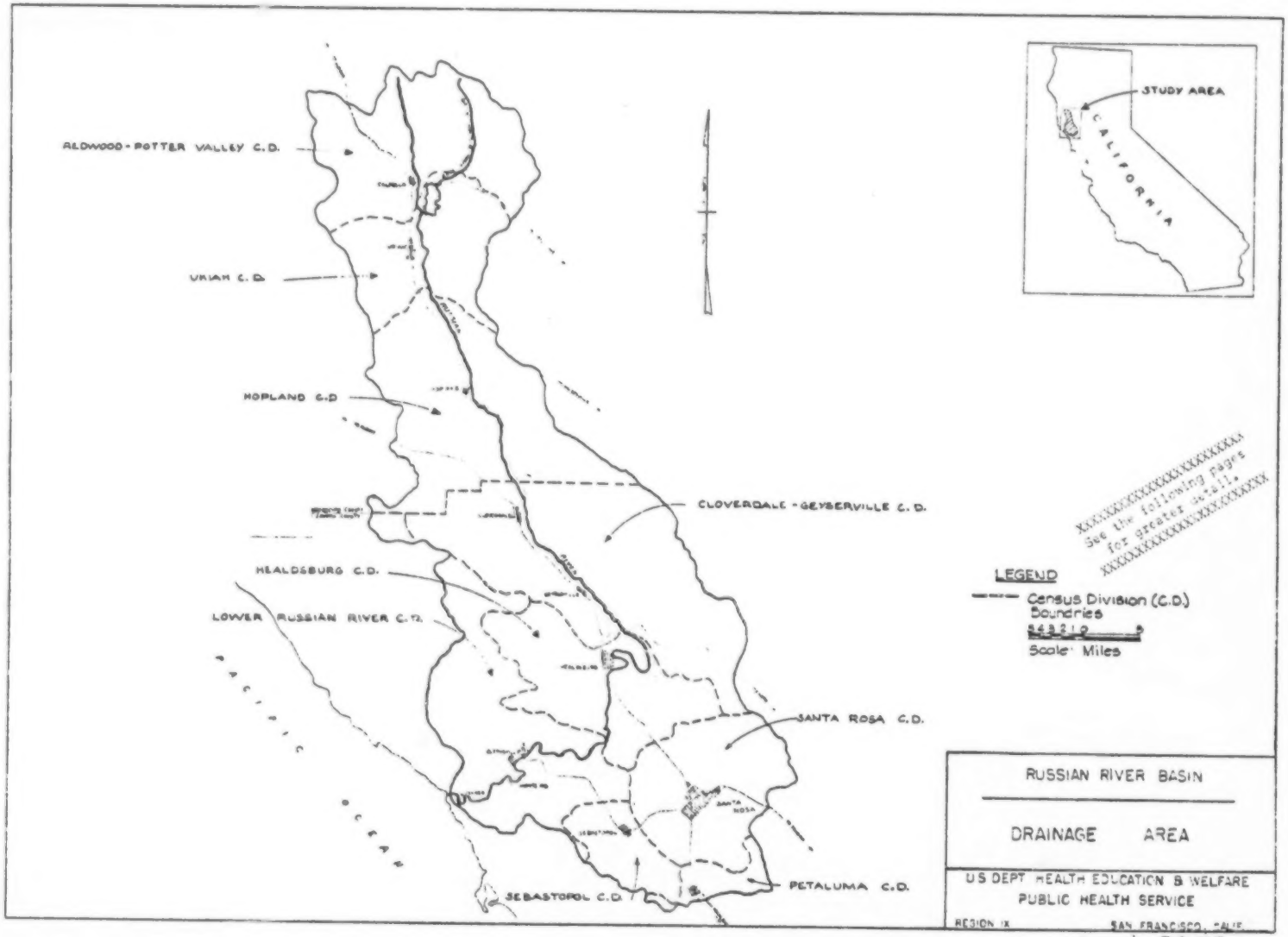
providing comparable quality water. If this benefit is assumed to be equal to the cost of maintaining water quality in the secondary treatment - river disposal situation - then the benefit is the sum of treatment costs plus the cost of the additional water used for quality control. This figure is the sum of rows 4,5 and 8, or 1,310 + 1,425 + 0 = $2,735.

This benefit can be compared with the costs of achieving it, for each alternative as shown in the sum of rows 4, 5 and 8 in Table C-2.

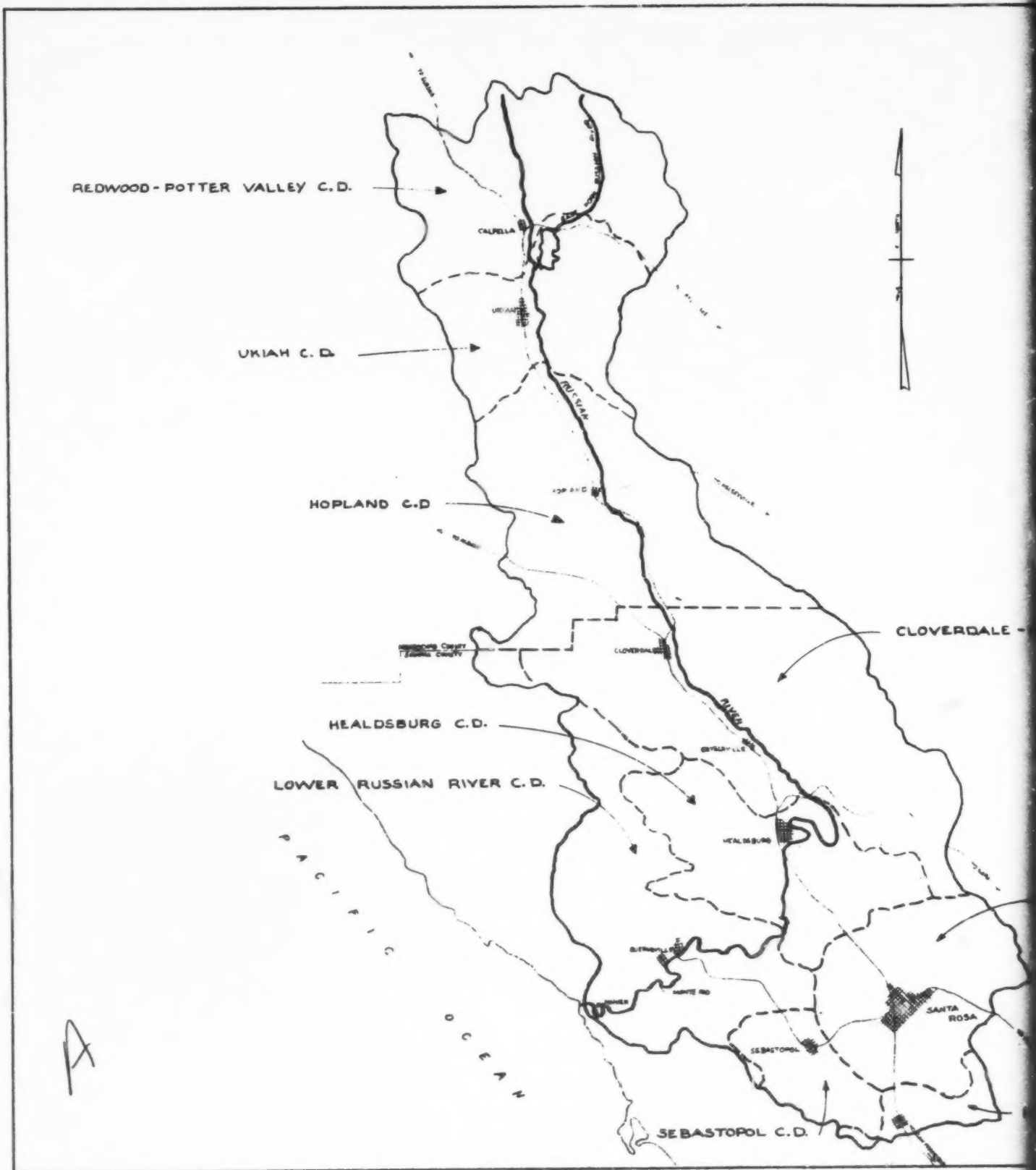
Dividing the benefit, as measured by costs of alternative (a) by the costs of the other alternatives gives a rough measure of benefit-cost ratio based on costs. For a water cost of $10 per acre-foot, the ratios are shown in row (d) of Table C-2.

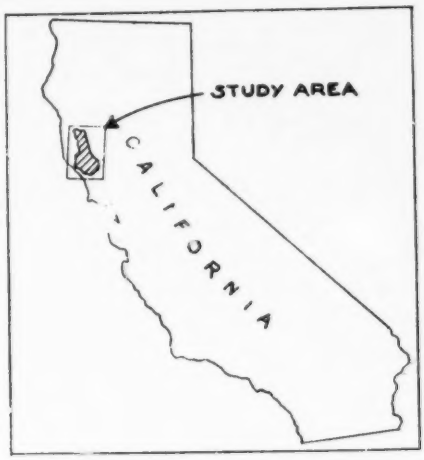
Different ratios result from different water costs. These are shown in row (e) - cost of water at $5/acre-foot, and row (f) - cost of water at $20/acre-foot. The "best" disposal alternative is a function of the cost of water, as would be expected.

Having saved some water, there may be some net benefit associated with this water which could change the project formulation. If this water can be developed at a cost less than its value in a use, then there will be additional net benefits from choosing an alternative disposal scheme.


ALDWOOD - POTTER VALLEY C.D.
UKIAH C.D.
HOPLAND C.D.
CLOVERDALE - GEYSERVILLE C.D.
HEALDSBURG C.D.
LOWER RUSSIAN RIVER C.D.
SANTA ROSA C.D.
PETALUMA C.D.
SEBASTOPOL C.D.
PACIFIC OCEAN
STUDY AREA
CALIFORNIA
XXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXX
LEGEND
Census Division (C.D.) Boundries
Scale: Miles
RUSSIAN RIVER BASIN
DRAINAGE AREA
US DEPT. HEALTH EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION IX SAN FRANCISCO, CALIF.

C-8 FIGURE 1


REDWOOD - POTTER VALLEY C.D.
UKIAH C.D.
HOPLAND C.D
CLOVERDALE -
HEALDSBURG C.D.
LOWER RUSSIAN RIVER C.D.
SEBASTOPOL C.D.
RUSSIAN
RIVER
CALPELLA
UKIAH
HEALDSBURG
SEBASTOPOL
SANTA ROSA
PACIFIC OCEAN



CLOVERDALE - GEYSERVILLE C. D.

SANTA ROSA C. D.

PETALUMA C.D.

SEBASTOPOL C.D.

LEGEND

Census Division (C.D.) Boundries

Scale: Miles

RUSSIAN RIVER BASIN

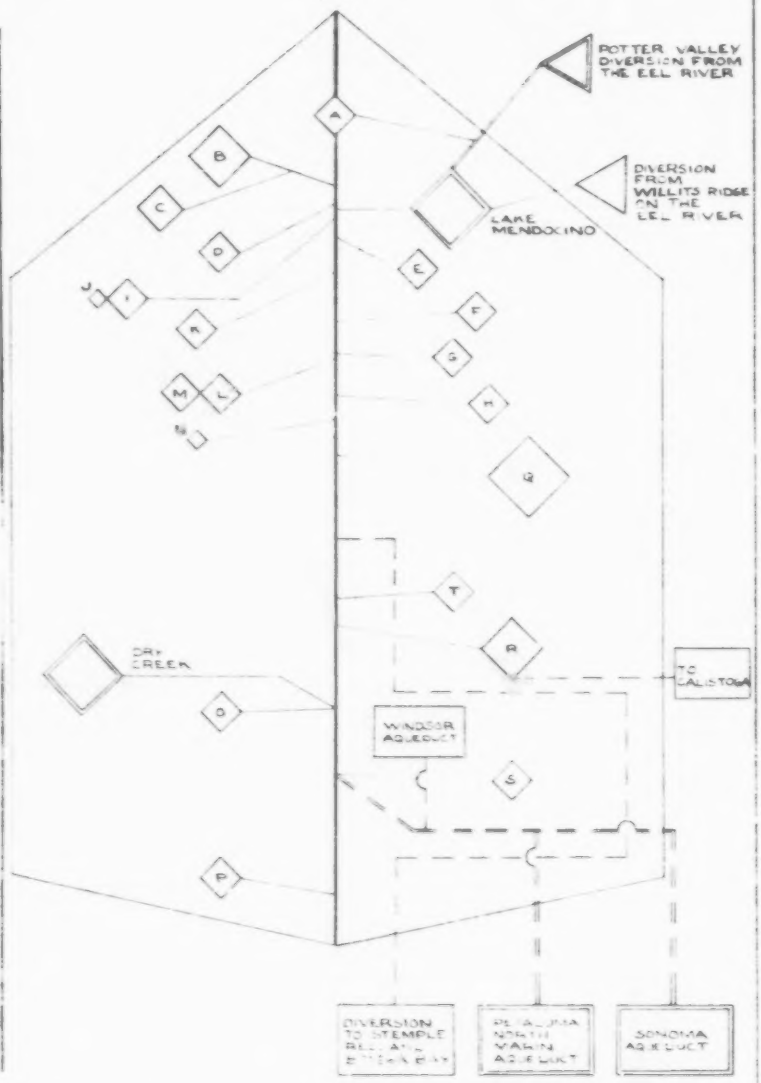
DRAINAGE AREA

US DEPT HEALTH EDUCATION & WELFARE
PUBLIC HEALTH SERVICE

REGION IX SAN FRANCISCO, CALIF.

C-8 FIGURE 1

PRELIMINARY PROJECT DATA FROM THE CORPS OF ENGINEERS		
Reservoir	Minimum Fish Releases cfs	Water Conservation Yield AF/YR
(A) Redwood Valley	2.5	12,600
(B) Forsythe Creek	2.5	30,000
(C) Seward Creek	2.5	10,500
(D) York Creek	1.5	7,000
(E) Vichy Springs	0	5,800
(F) Parsons Creek	1.5	2,000
(G) McDowell Creek	6.0	9,200
(H) Pieta Creek	0	15,400
(I) Lower Ackerman Creek	5.0	7,500
(J) Upper Ackerman Creek	1.0	1,800
(K) Robinson Creek	5.0	10,200
(L) Lower Felix Creek	10.0	13,500
(M) Upper Felix Creek	7.5	10,000
(N) Cummisky Creek	2.5	3,900
(O) Mill Creek	5.0	10,500
(P) Bear Pen	5.0	10,000
(Q) Big Sulphur Creek	25.0	52,000
(R) Knights Valley	10.0	37,800
(S) Mark West Creek	7.5	9,000
(T) Sausal Creek	5.0	6,900



— SYMBOLS —

RESERVOIRS

YIELD OVER 50,000 AF/yr

YIELD 20,000 - 50,000 AF/yr

YIELD 5,000 - 20,000 AF/yr

YIELD UNDER 5,000 AF/yr

WATER DIVERSION

AQUEDUCT

PROPOSED

AUTHORIZED OR EXISTING

RUSSIAN RIVER BASIN

WATER RESOURCES DEVELOPMENT DIAGRAM

U.S. DEPT. HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION IX SAN FRANCISCO, CALIF.

FIGURE 2

C-9

Reproduced from best available copy.

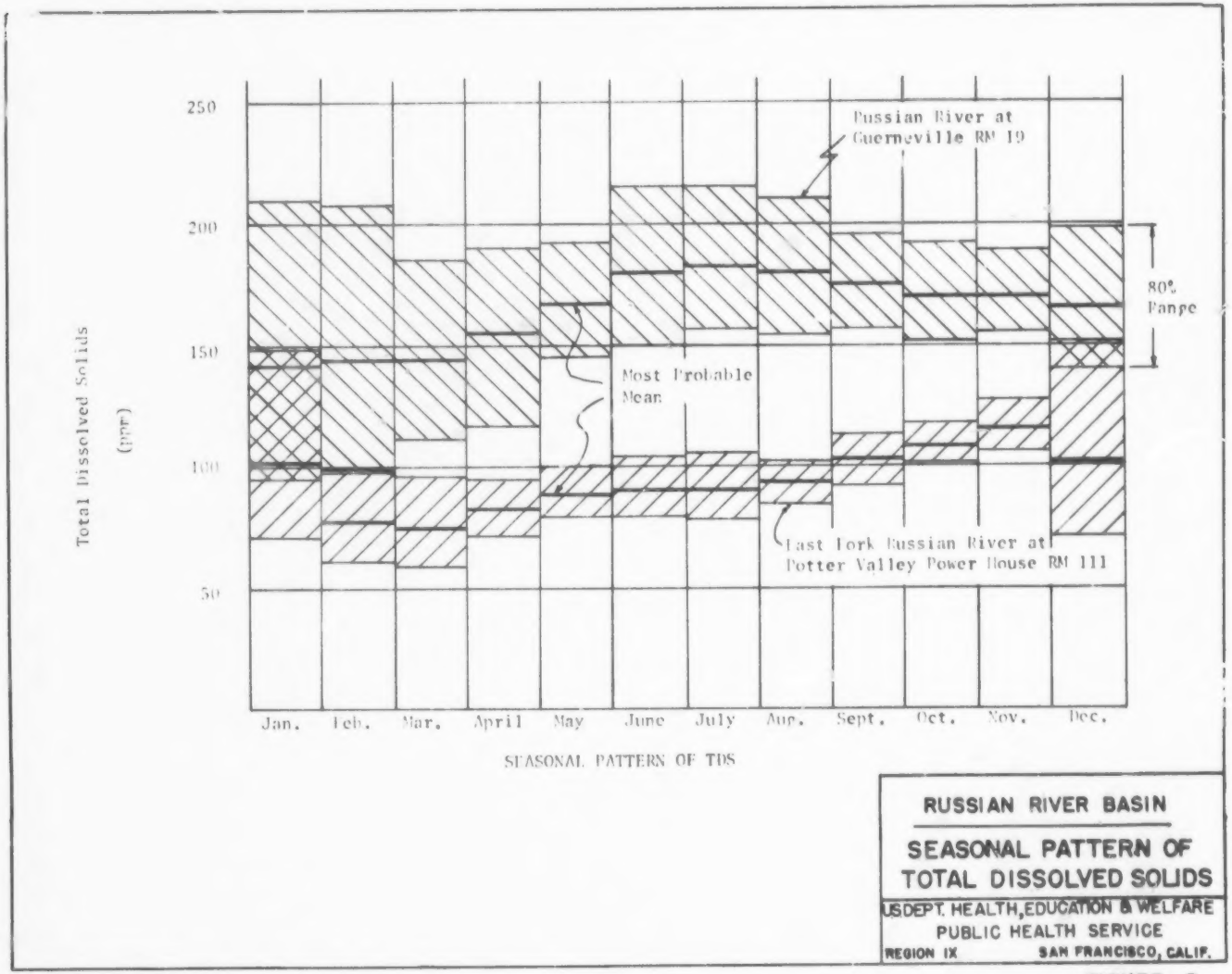
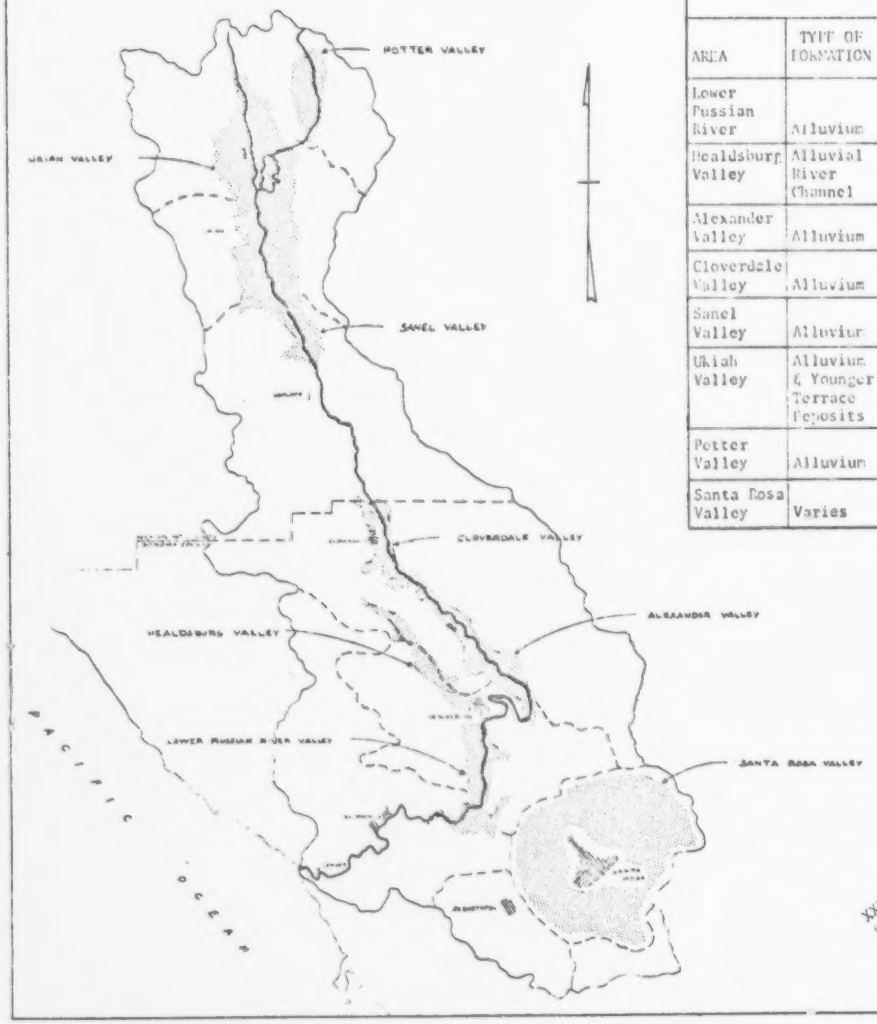

250
200
150
100
50
Total Dissolved Solids
(ppm)
Russian River at
Guerneville RM 19
80%
Range
Most Probable
Mean
East Fork Russian River at
Potter Valley Power House RM 111
Jan.
Feb.
Mar.
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
SEASONAL PATTERN OF TDS
RUSSIAN RIVER BASIN
SEASONAL PATTERN OF
TOTAL DISSOLVED SOLIDS
USDEPT. HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION IX
SAN FRANCISCO, CALIF.

FIGURE 3



GROUND WATER BASIN STORAGE CAPACITIES

AREA	TYPE OF FORMATION	ESTIMATED STORAGE CAPACITY Acre-Feet	WELL DRAWDOWN ESTIMATES gpm/ft. of Drawdown
Lower Russian River	Alluvium	47,000 (total storage capacity) 25,500 (storage to 50 ft. depth)	X
Healdsburg Valley	Alluvial River Channel	70,000 (storage 10-50 ft.depth)	50 to 200
Alexander Valley	Alluvium	50,000 (storage 10-50 ft. depth)	10 to 100
Cloverdale Valley	Alluvium	15,000 (storage to 25 ft. depth)	Better than other Valleys
Sanel Valley	Alluvium	20,000 (storage 10-50 ft. depth)	20 to 100
Ukiah Valley	Alluvium & Younger Terrace Deposits	75,000 - 100,000 35,000 (storage 10-50 ft. depth)	5 to 400
Potter Valley	Alluvium	10,000 (storage 10-50 ft. depth)	1 to 5
Santa Rosa Valley	Varies	1,017,000 (storage 10-200 ft. depth)	X

5 4 3 2 1 0 5

SCALE: MILES

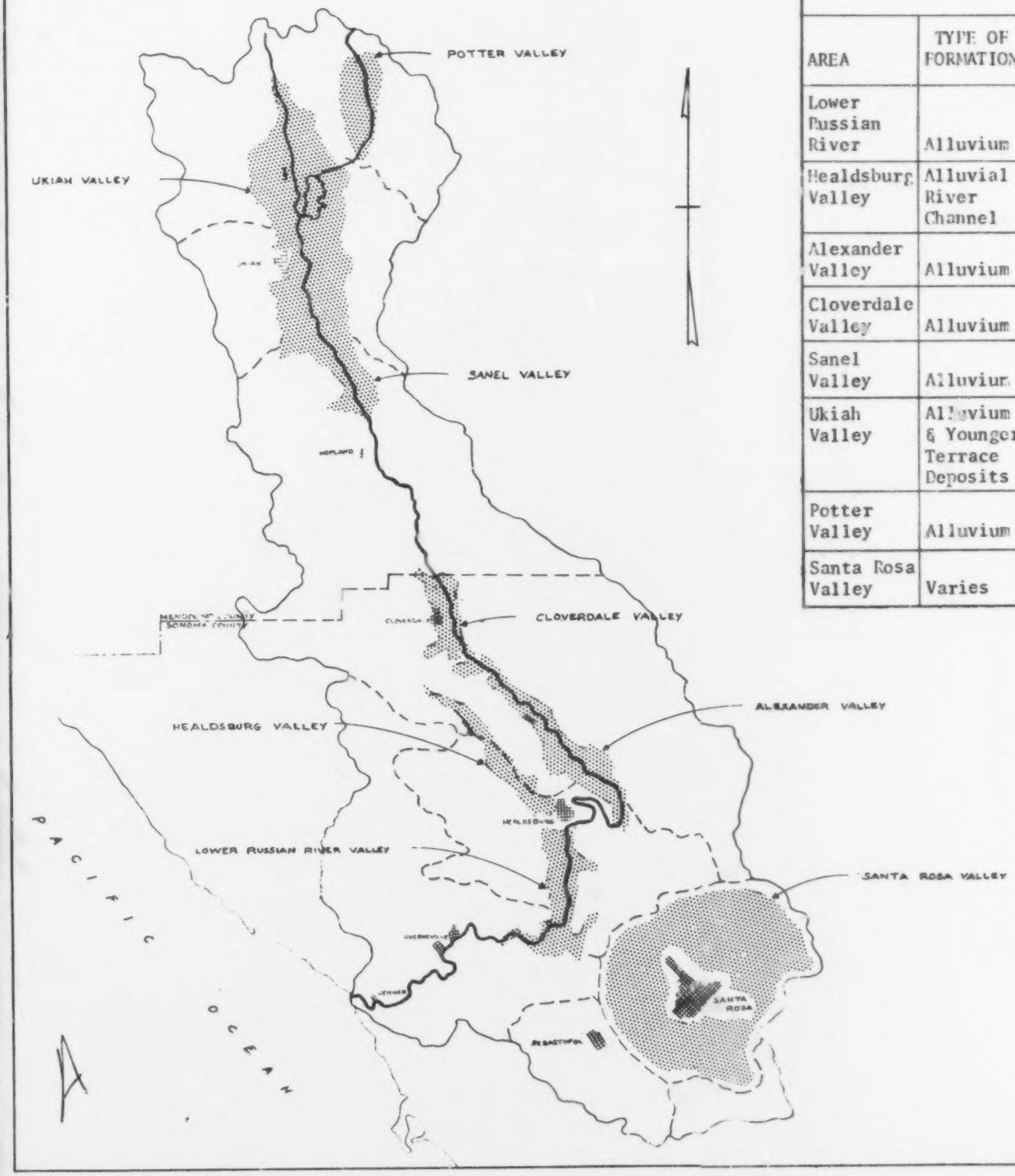
XXXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXXX

RUSSIAN RIVER BASIN

GROUND WATER BASINS AND STORAGE CAPACITIES

U.S. DEPT. HEALTH EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION IX SAN FRANCISCO, CALIF.

FIGURE 4



GROUND WATE		
AREA	TYPE OF FORMATION	ESTIMAT
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Sanel Valley	Alluvium	20,000
Ukiah Valley	Alluvium & Younger Terrace Deposits	75,000 35,000
Potter Valley	Alluvium	10,000
Santa Rosa Valley	Varies	1,017,000

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543210 5
SCALE: MILES

B

RUSSIAN RIVER BASIN

GROUND WATER BASINS AND STORAGE CAPACITIES

U.S. DEPT. HEALTH EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
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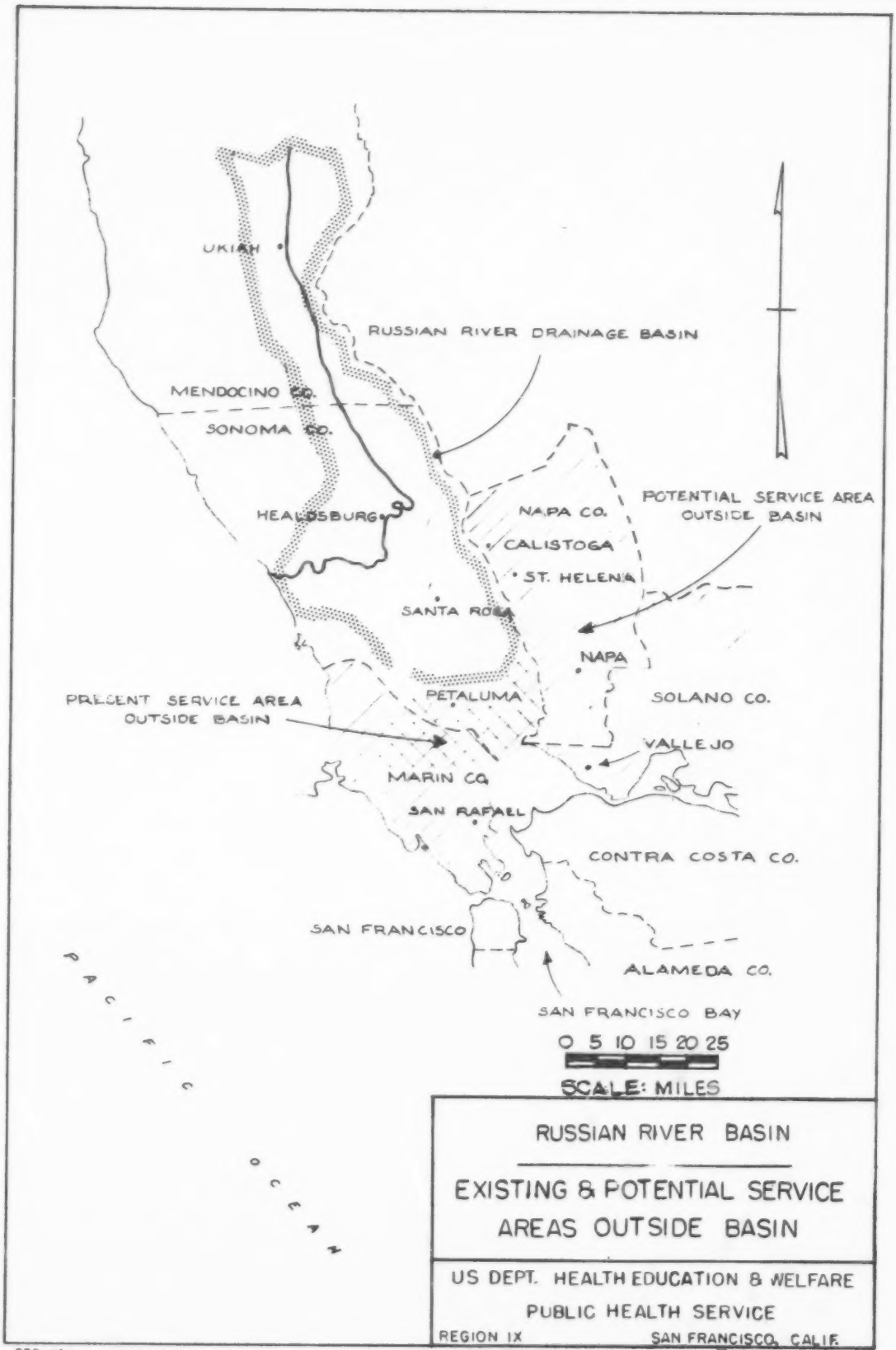
C-11

FIGURE 4



RUSSIAN RIVER BASIN

EXISTING & POTENTIAL SERVICE AREAS OUTSIDE BASIN

US DEPT. HEALTH EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION IX SAN FRANCISCO, CALIF.

GPO 968-016

FIGURE 5